Course of Study in Science for Secondary Schools

BULLETIN 400

COMMONWEALTH OF PENNSYLVANIA

Department of Public Instruction • Harrisburg

ATOMIC EXPLOSION AT BIKINI

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THE use of the painting, The Ice Cap, on the cover of this bulletin is made possible by the courtesy of the artist, Captain Charles Bittinger, and the cooperation of the Combat Art Section, Division of Naval Records and History, Navy Department, Washington, D. C.

The artist's view shows the nitrogen oxide apricot-hued mushroom at about 25,000 feet. Condensing gases formed the ice cap. The uranium atoms exploded with the energy that lights the stars. The mushroom rose swiftly and silently above the Bikini lagoon.

Whether the exquisite phenomenon shall be a thing of beauty for man, extending his control over nature's laws, or something sinister by which he may destroy himself, is the challenge of our day. Science education, with its many social implications, will do much to translate this achievement into human values as colorful as the artist's vision.

Course of Study in Science
for
Secondary Schools

A PROGRESS REPORT

BULLETIN 400
1951

Commonwealth of Pennsylvania
DEPARTMENT OF PUBLIC INSTRUCTION
HARRISBURG

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FOREWORD

The need for a secondary school course of study in science is evident. The impact of scientific development upon the lives of people is most significant. Science education has not only a responsibility to foster and advance that development, but also to help create in all youth the understandings, attitudes, and behaviors that are needed for social competence in an age of jet propulsion and atomic fission.

This bulletin reviews and reports research in science teaching. It selects, describes, and gives examples of the best practices that can be found. It indicates how good practices can be applied in classrooms and laboratories, and it suggests scope and sequence for local planning by teachers in the several secondary school science fields. Recommendations are made which both experienced and inexperienced teachers will find useful, instructive, and stimulating. It is hoped that marked progress in science education will result from this Progress Report, thus producing further revision and enrichment.

Grateful acknowledgment is made to the State Production Committee and to the many science teachers who have helped in the preparation of this bulletin. Chester B. Dissinger, Superintendent of Schools of Pike County, Milford; Carl E. Whipple, Superintendent of Schools, Warren; J. Paul Burkhart, Superintendent of Schools of Cumberland County, Carlisle; Samuel E. McDonald, Superintendent of Schools, Coatesville; David H. Stewart, Superintendent of Schools, Dormont; and G. Arthur Stetson, Superintendent of Schools, West Chester, have reviewed the manuscript. This bulletin has been edited by Rachel S. Turner, Editor for the Department.

Francis B. Haas

Superintendent of Public Instruction

May 1951

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INTRODUCTION

In the production of this bulletin, many excellent suggestions, courses of study, and units have been received from teachers in the field. Much helpful advice has been gathered from consultants and from authoritative sources in science education. In the assembling of material, the committee was guided by the results of a questionnaire regarding felt needs which was circulated among the science teachers of the State. The frequency of expressed needs for material, made by the respondents, guided the organization of the Progress Report.

A representative sampling of the replies of teachers indicated the following needs.

		Per cent
1.	Outline of course content for secondary school science fields	88
2.	Suggested procedures with academic and nonacademic students	85
3.	List of resources—community, speakers, places to go, visual aids, etc.	84
4.	Photographic and other illustrative material	82
5.	Suggestions for cooperation with other secondary-school subject teachers	76
6.	A philosophy of science education	69
7.	A statement of principles and general objectives	65
8.	Suggestions for experimentation in educational methods and materials with class groups	62
9.	Recommendations for time allotment for class periods	57
10.	Recommendations for classroom and laboratory arrangements	42

Further requests included: (1) examples of good practices, (2) experience units, (3) procedures for evaluation, (4) suggestions for student participation in planning, (5) suggestions for individual attention in heterogeneous groups, (6) suggestions on how to teach pupils to study science, (7) methods to determine the personal and social needs of pupils and to integrate science education with personal and social experience, (8) effect of curriculum trends on current practices and methods, (9) issues in science education, and (10) ways by which science education can be made meaningful and functional to students.

These requests have led to the state-wide gathering of material. This material, arranged in logical sequence, constitutes this Progress Report. At the same time, a look at the requests provides a view of what science teachers say that they need now and will continue to need. They indicate to teachers, professors, and committees the place for a continuous de-

velopmental program with the interchange of written reports and materials. Here is a challenging opportunity for teachers interested in curriculum improvement to provide continuously suggestions and experiences which will be of help to others.

What Teachers Want

Teachers in general want practical help which they can get readily when time is not available for much study and experimentation. For some there is an ever-living thrill in working with students and science materials to achieve the greater goals of education. For the scientist and the educator both, the drama of discovery, invention, and help to humanity, is an ever-present challenge. The search for means and processes for the creation of better products frequently transcends all obstacles.

There is nowhere a scientifically constructed course of study in science or in any other subject. The needed exhaustive experimentation on what content should best be included at what grade levels, on what the best sequence of content should be, or on what learning activities should best be carried on with various types of pupils has not been made. Hence, there is again the challenge for continuous experimentation by people who are in contact with youth and with science materials.

In order to secure your reaction to the material in this bulletin, a check list is provided on page xvii. It is requested that this be cut out or reproduced after six months by all users of Bulletin 400, and that it be sent or delivered to the district chairman who is listed on the Production Committee. Such critical evaluations and suggestions will serve to produce a later revision of this Progress Report.

Using a Course of Study

A modern course of study is suggestive and not prescriptive. When content mastery was considered the sole aim of education, prescriptive courses were common. The creative development by individual teachers of the greater goals of education—understandings, attitudes, and desirable behaviors—makes prescription of teaching methods impossible. The aims, methods, and incentives of science teachers vary too greatly for rule-of-thumb recommendations.

Each one may learn by experimenting for himself and trying out the successful experiences of someone else. A modern course of study, with grass-roots assistance, seeks to point the way toward greater goals and to provide general suggestions. It points out areas of possible professional growth and provides challenges for their achievement. As in all professions, research and the work of pioneer thinking in science education also provide practical ideas on how to do things and to get things done. These suggestions point the ways for teacher tryout and evaluation. They are not measures for immediate success or failure. Each teacher may through his own experiments and evaluations discover new challenges and increasing measures of success.

In Chapter I, PROBLEMS OF SCIENCE EDUCATION, general problems are raised. Research and reports on science education are cited. Chapter II, ACHIEVING GREATER GOALS IN SCIENCE EDUCATION, suggests ways by which progress toward solving problems of science education is being made by many teachers. Chapter III, SCOPE AND SEQUENCE, becomes specific in describing some of the values of the various sciences and proposes units for their realization. Chapter IV, EVALUATION, is concerned with the development of means of appraising results.

These chapters, together with Chapter V, suggest: (1) an unfolding problem, (2) reports and data concerning the problem, (3) a work plan for solution by both teacher and pupil, and (4) suggested ways for measuring progress.

The user of this Course of Study may consider the application of suggestions and good practices to his own situation and to his own problems, may report on his evaluation of outlined procedures, and may share with others the results of his critical tryout of lesson plans, teaching aids, school trips, life-problems units, standardized or homemade tests, pupil questionnaires, class or individual projects, pupil-teacher cooperative planning, and the like. Through this cooperative effort, science education will become increasingly effective.

REPORT OF REACTION
ON
BULLETIN 400
COURSE OF STUDY IN SECONDARY SCHOOL SCIENCE
A PROGRESS REPORT

NOTE: The user of Bulletin 400 is requested to fill out this report, after a semester of use, and to send it to the science committee chairman of the district (See Production Committee, page iv).

Have the following been of practical use to you?

		Check
CHAPTER I. PROBLEMS OF SCIENCE EDUCATION	Yes___	No___
CHAPTER II. ACHIEVING THE GOALS OF SCIENTIFIC EDUCATION		
1. Teaching Science by Units	Yes___	No___
2. Improving Science Teaching	Yes___	No___
3. Meeting the Imperative Needs of Youth	Yes___	No___
4. Teaching Students to Study Science	Yes___	No___
5. Helping Pupils to Solve Their Vocational Problems in the Science Fields	Yes___	No___
6. Cooperating with Teachers of Other Subjects	Yes___	No___
7. Summary	Yes___	No___
CHAPTER III. SCOPE AND SEQUENCE		
1. Scope and Sequence	Yes___	No___
2. Science in the Junior High School		
a. Grade seven	Yes___	No___
b. Grade eight	Yes___	No___
c. Grade nine	Yes___	No___
3. Science in the Senior High School		
a. Biology	Yes___	No___
b. Chemistry	Yes___	No___
c. Physics	Yes___	No___
d. Physical Science	Yes___	No___
CHAPTER IV. EVALUATION	Yes___	No___
CHAPTER V. REFERENCES AND RESOURCES	Yes___	No___

What constructive suggestions can you make for future deletion, inclusion, or enrichment in the above chapters? Use the other side for further notes:

CHAPTER I. ....

CHAPTER II. ....

CHAPTER III. ....

CHAPTER IV. ....

CHAPTER V. ....

What is your general opinion of the Bulletin?
(Use other side for comments.)

COURSE OF STUDY IN SCIENCE

CHAPTER I

PROBLEMS OF SCIENCE EDUCATION

ACHIEVEMENTS OF SCIENCE TEACHING

SCIENCE education has had a dual achievement in assisting all youth to grow toward maturity and in transmitting and adding to the racial heritage of scientific skill and understanding. Both of these objectives have been uppermost in science teaching in Pennsylvania. The aspects of this twofold achievement have been complementary. Concentration in either area toward still greater goals would produce a course of study that would be out of step with the concerns and demands of education.

The first aspect of achievement, assisting youth through science education to grow toward maturity, gains increasing importance as study reveals the personal and social tensions of modern society. The facts and know-how which research has developed indicate that in the last half of the twentieth century the most significant development in science education will be through its increasing contribution to the all-round growth of its students as individuals for life in American and world society.

The impact of science upon modern life bears witness to the help of secondary education in *the second aspect of achievement, passing on and adding to the racial heritage of scientific knowledge and skill.* Effective learning involves organization around the concepts and principles of science. When the details are cut away, the essential principles for both personal growth and technical skill become apparent.

However, there may be a gap between what is known about science education and the basic needs of youth and the continuous use of that knowledge in achieving greater goals. The basic problem of every science teacher is to provide a curriculum for youth in secondary school

science that will be as *functional* as possible both for everyday living and for work in the technical fields. New knowledge and research should have a significant impact upon curriculum planning.

SELECTING THE OBJECTIVES OF SCIENCE EDUCATION

The framing of objectives is a continuous process. As committee research and personal experiments and reports create keener insight, new horizons are revealed. This fact is shown in national science reports and recommendations:

1. *In the report of the Educational Policies Commission,* science education is called upon for an important part in life adjustment education.[7] More specific objectives of science education for each American youth are to:

> (1) Equip him to enter an occupation suited to his abilities and offering reasonable opportunity for personal growth and social usefulness, (2) prepare him to assume the full responsibilities of American citizenship, (3) give him a fair chance to exercise his right to the pursuit of happiness, (4) stimulate intellectual curiosity, engender satisfaction in intellectual achievement, and cultivate the ability to think rationally, and (5) help him develop an appreciation of ethical values which should undergird all life in American society.

2. *In another recent report, that of the Harvard Committee on General Education*[12], the point of view concerning science education is that:

> Science instruction in general education should be characterized mainly by broad integrative elements . . . the comparison of the scientific method with other modes of thought . . . the relation of science with the problems of human society.

3. *The Thirty-first Yearbook of the National Society for the Study of Education holds that:*[19]

> The major generalizations and associated scientific attitudes are seen as of such importance that understandings of them are made the objectives of science teaching. . . . They touch life in so many ways that their attainment as educational objectives constitutes a large part of the program of life enrichment.

4. Again, in 1947, a committee of the National Society for the Study of Education in *Science Education for American Schools* set up five criteria for objectives:[18]

> First, a statement should be practical for the classroom teacher. Second, it should be psychologically sound. Third, it should be possible of attainment. Fourth, it should be universal. And fifth, it should show the relationship of classroom activity to desired changes in behavior—how the student thinks, feels, and acts.

NOTE: Superior numbers throughout the chapter's content refer to numbered items in the Suggested Readings on pages 11-12 at the end of the chapter.

Based on these criteria, the committee proposed the following types of objectives:

1. Functional information or facts
2. Functional concepts
3. Functional understanding of principles
4. Instrumental skills
5. Problem-solving skills
6. Attitudes, appreciations, and interests

These four reports and the committee's types of objectives provide guiding principles for teachers: (1) for the selection of science problems and learning activities and (2) for a type of evaluation that will show the progress attained in the several areas. They challenge the formation of objectives by every teacher and the development of the professional skill which is necessary to teach for understanding, problem-solving skills, attitudes, and appreciations. They are viewed best as directions for progress rather than as immediate measures of teaching success or failure.

The learner in science will use his functional data, concepts, and understanding in everyday life. They will help him to explain phenomena, to predict what will happen, and to create desired effects. He should apply concepts to new situations which he has not met before. To achieve these objectives, the method of instruction must create many opportunities and activities for meaningful learning situations.[19]

SELECTING THE CONTENT OF SCIENCE EDUCATION

In many situations, the science textbook is the course of study. However, the viewpoint of the textbook author and specialist in science education is that:

> The textbook should be a source of data for solving the problems of the student which he needs to solve. It answers the questions in which he is interested. It helps him to understand the generalizations by providing the reading material over which he can mull and reread as often as he wishes. . . . It is not something to be learned. It is merely a source of data which, when properly used, may result in learning. It is but one of many sources and should be used in that respect.[3]

Sterile formality in teaching cannot be blamed on the textbook. The fault lies in how the textbook is used. Learning is doing, experiencing.[11] The aim is not only content mastery but changes in the behaviors of the learner. Textbooks, courses of study, lesson plans, and experience units have value not in what they do for students but in what they lead students to do for themselves. There is no learning without doing. Doing, in inductive problem-solving activity with the use of references, should

precede intensive book study. The recitation, as a matter of general practice, has become an unscientific relic.[13]

COURSE OF STUDY, UNIT, AND LESSON PLANNING

Planning is a necessary procedure in any departure from formal textbook assign-study-recite teaching. Things are done because they are planned on paper. A course of study can be of help in this process. In it, suggested sample units are developed in outline to indicate: (1) basic content (usually as problems, understandings, or concepts), (2) objectives, (3) suggested learning activities, and (4) suggested types of evaluation. The user may desire to develop similar units or better ones, or life-problem units which are based directly upon objectives or unique needs.

Most planning in this bulletin has taken the following form: (1) a unit title, (2) a significant problem or principle that has wholeness and (3) consideration of:

What?	*Why?*	*How?*	*How Much?*
CONTENT	OBJECTIVES	LEARNING ACTIVITIES	EVALUATION
Concepts Principles Understanding Problems	Imperative needs of youth Life adjustment goals Functional life uses Scientific values Industrial uses	Class trips Committee work and reports Debates Demonstrations Experimentation Group discussions Interviews Investigations Problems Projects Pupil planning, etc.	Subject matter tests Performance tests on the use of concepts Attitude scales Anecdotal diaries Pupil diaries Self-evaluation check lists Need for drill? Pupil inventions

Objectives

For effective expression, the second column—objectives—must be emphasized. These objectives involve the functional use of concepts and understandings in the content outlines. They have place and status in the sequence outlines in Chapter III. Their achievement depends upon and determines the extent of content mastery. If the learner helps to plan the objectives, activities, and means of evaluation, he identifies himself with the learning in a way that contributes greatly to achievement. Factual mastery will be increased in the functional setting which is created.[1]

Activities

The learning activities customary in science education are an antidote for shallow verbalism. Activities are based on the objectives. At the same time, they provide work plans and pupil groupings to take care of: (1) individual differences and incentives (pretechnical and terminal aims), (2) group practices in democratic action, and (3) the use of deductive and inductive reasoning. The learner should grow in understanding through his own experience in working with a group in searching for data, weighing evidence, forming and evaluating hypotheses, and coming to conclusions. This type of teaching is needed both for life adjustment and for pretechnical preparation.

Such planning for lateral enrichment is not difficult or time-consuming. Initially some written plans or the use of flexible course of study units will be an aid. Later success brings the satisfaction which only pupil participation and spontaneity can provide. Much curriculum improvement is being developed in this manner. More specific discussion is included in Section 1, Chapter II, "Achieving Greater Goals in Science Education."

SELECTING THE APPLICATIONS OF SCIENCE EDUCATION

A wise choice of applications has taken into account the contributions which science makes to the natural biological tensions or needs of youth. The planning of learning activities to contribute to imperative pupil needs is of great importance. This is expressed in the 1950 *Evaluative Criteria*. Scientific understandings and learning activities are the means by which students acquire practice in the adjustments which are needed in growing up in a scientific era.

THE NEEDS OF YOUTH

Wise planning for functional objectives depends upon a knowledge of pupil needs. Pupil needs and "leads" have been divided into two general classifications: (1) those which are *general for all youth* whether they will become carpenters or chemists, and (2) those which are *specific for the individual* in accord with abilities, ambitions, future plans, and cultural and economic backgrounds.

The first classification, *General Needs,* is the easier to determine. Long study has been given to this problem. The National Association of Secondary-School Principals has provided a list of *The Ten Imperative Needs of Youth* which is recognized as basic.[8] In a Pennsylvania survey, 98 per cent of the teachers and 80 per cent of the pupils expressed approval of this list.[5] (See Chapter II, Section 3 and the chart on page 7.)

The second classification, *Specific Needs,* is more difficult. This involves the study of each individual, his scholastic records, his college or

vocational intentions, results of testing programs, vocational plans, conference results, family background, and personality traits. In these special needs, each youth presents an individual problem that must be considered in planning.

A list or survey of needed life adjustments may be developed by each school faculty as an effective in-service learning experience. The "Inquiry on Student Needs" which is included in Bulletin 243, *Curriculum Improvement by a Secondary School Faculty,* Department of Public Instruction, Harrisburg, Pa., 1950, provides an excellent method for such a survey.

USE OF LIFE-PROBLEM UNITS

Problem solving, scientific thinking, suspended judgment, consideration of all available facts are the best procedures for developing both technical learning and growth toward maturity.

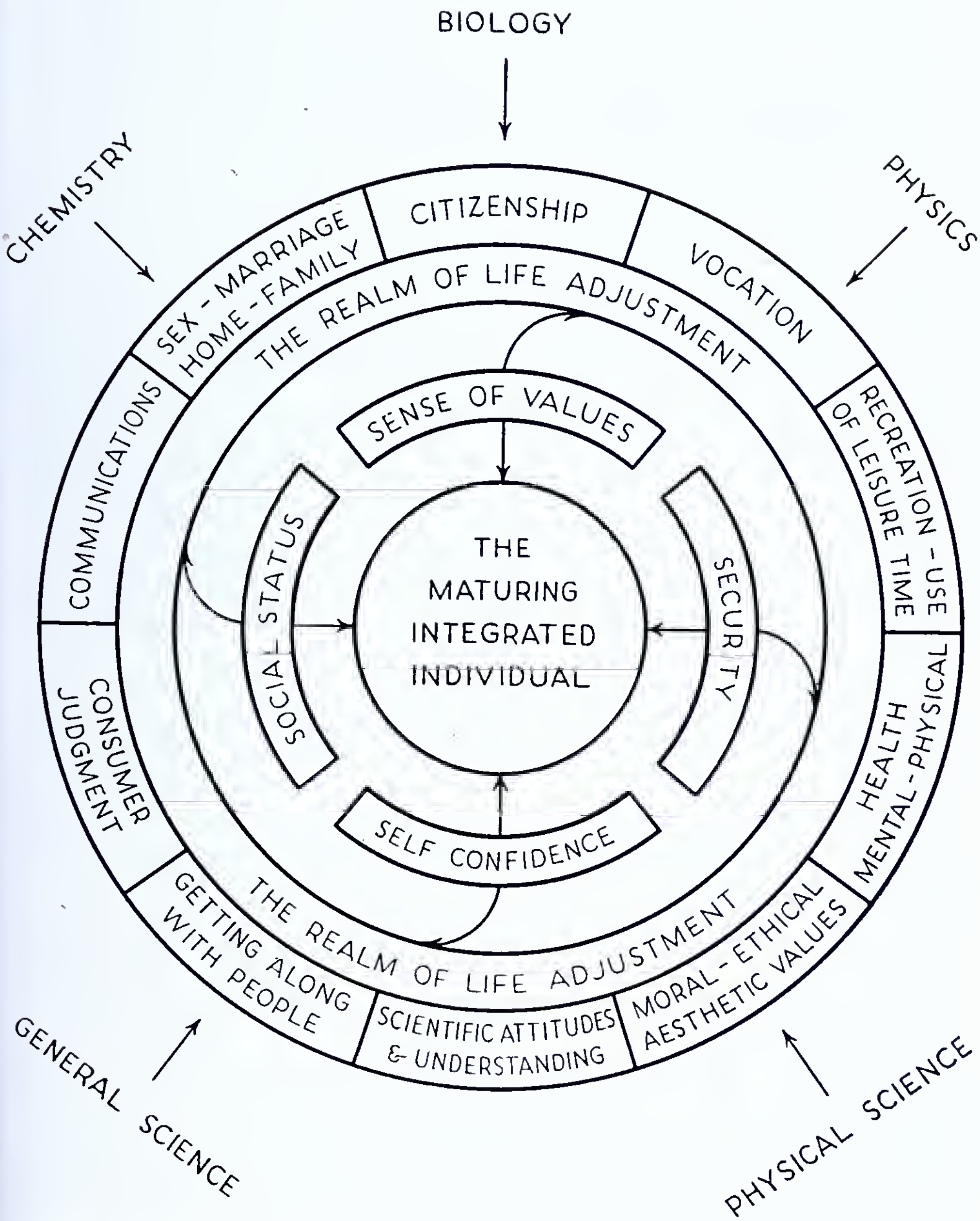
As Overstreet has written: "This is the secret of all mind building in children. Find the problems which are real to them and help them work out the solutions."[16]

Science teachers bring many basic life problems and scientific practices to youth in order that they may grow well into maturity and take their places in community life. Science education plays a vital role in assisting youth to realize immediate needs and to develop greater ones. The teaching for retention that attains the desired functional objectives consists in providing practice in the use of science and its methods in meeting and solving the all-round problems of personal, social, and vocational adjustment.

Life problem units, based directly on objectives, frequently can be interposed in a content-centered course of study. These are focused upon problems of living. What career shall I choose? How can I keep well? What is scientific thinking? What causes most people to act the way they do? How can I learn to appreciate nature? How can I learn to get along with other people? How shall I choose a life mate? What criteria will help me in building or buying a home? These and similar problems are of great importance to youth. Opportunities for the consideration of many of these exist only in science education.

The loss of 54 per cent of Pennsylvania's secondary school youth through dropouts and the serious lowering of enrollments in formal science courses[18] are facts which emphasize the need for planning of life-problem units in all science courses.

The diagram on page 7 pictures the Imperative Needs of Youth in growing into maturity. Here is a framework within which many



THE GOALS OF SCIENCE EDUCATION

subject disciplines can operate and cooperate. The emphasis is upon the integrated individual—the whole educational product—together with special emphasis on proficiency, growth, and development in four critical areas which earmark such an individual.[4] The pattern of life adjustment is the way the learner thinks, feels, and acts in achieving self-realization. These imperative needs are also goals of science education. On them are focused the learning units in any course of study.

MEETING SPECIAL PUPIL NEEDS

Of the pupils taking science courses, the percentage of those planning to continue formal education after high school varies greatly with the community served by the school. Such percentages of secondary school graduates range from 10 to 90, but average less than 10 per cent of all elementary and secondary pupils throughout the State.[11] The percentage of college preparatory pupils in a physics or a chemistry class is higher, but still dependent upon the socioeconomic status of the student. Determining the special scientific needs of these college-preparatory pupils is relatively easy since they require the type of functional preparation in the basic data, principles, laws, and applications upon which they can build in college.

Some teachers prefer homogeneous grouping for pupils of various types. Others can satisfy the needs of the groups by occasional subgrouping in the same class. Segregation of college and noncollege students or sectioning on ability levels is not the general rule. It may even be considered inadvisable or impossible. Thus a problem of some magnitude is presented.

Further reports of successful evaluated procedures are needed for a revision of this Progress Report. The following general suggestions have been provided:

1. *Scientific principles are the same for all students whether or not they are going to college, and regardless of their choice of occupation.* Research has indicated that specialized technical study is based most soundly on a good background of functional scientific understanding.[2] There should be a minimum number of concepts, understandings, and applications for each science subject which all students electing the subject should be expected to master.

2. *Differentiated assignments should be made or planned activities developed* to further the preparation of: (1) the college-preparatory group, (2) the students preparing for industrial occupations, and (3) the students following a terminal education program. Thus, science education—by grouping within groups or by committee work in unit

study—can meet the needs of these three groups according to their future plans. Direct teaching and drill have place in any program when the need arises.

3. *For many students, the course in physical science may prove to be the most satisfactory science elective.*

PLANNING A FUNCTIONAL COURSE OF STUDY

A functional course of study must represent an integration of content, pupil needs, social values, learning activities, and means of comprehensive evaluation. It cannot overemphasize any single segment. The problems which are involved in its planning require the best that modern education can provide.

Psychologists, research workers in education, and teachers in action have evolved several basic principles for more effective teaching. These results of a half century of research are generally accepted: (1) in modern textbooks on educational psychology,[10] (2) in books on teaching methods,[14] (3) in the 1950 edition of the *Evaluative Criteria* of the Cooperative Study of Secondary School Standards,[9] and (4) in reports of national science committees.[17-18]

The consensus of these sources is significant. They represent the development that comes from scientific research and growth in any profession. Variations in opinion promote progress, but research provides clarification for sound judgment. People need the "unity out of diversity" if they are to go forward together. Many teachers are already adopting these new principles in their work. National, State, and city curriculum programs are being allotted public funds for their implementation.

Some of these principles, briefly stated, follow in order that the user of this bulletin may be supported in his own thinking and may understand the bases for the suggestions which are made in the pages which follow.

ACHIEVING OBJECTIVES IN TERMS OF GROWTH IN DESIRABLE BEHAVIORS

The dual problem of helping youth to mature and to acquire desirable understandings and behaviors is more complex than has been assumed. It is made so by the principles that: (1) Desirable behaviors and understandings do not develop automatically as by-products of factual teaching. (2) Each objective requires direct provision for its practice in active learning situations. (3) Essential values lie in the understanding of basic concepts and practice in their application in everyday life.

The customary teaching and testing of informational data alone have been found to have little effect on genuine learning. Teaching that does not change the way in which the learner behaves—thinks, feels, and acts—does not achieve the purposes of either life adjustment or precollege education.

The following considerations are derived from this fundamental agreement:

1. Functional Understanding

There is a distinction between memorized learning of inert ideas and functional understanding. Functional values—which are meaningful to the learner in terms of his life and needs—create intense participation and real learning. The satisfaction of immediate needs provides "leads" for further achievement and greater goals. The learner remembers what he uses and needs to know.[10]

2. Concrete Experiences

Effective learning moves from the concrete and familiar to the more abstract and remote. But always generalizations must function in the life of the learner. Youth instinctively resists learning that appears useless and trivial.

3. Participation in Learning Activities

Without the participation of the learner in many types of learning activities, there is excessive memorized learning.[13] Daily assign-study-recite-quiz procedures encourage temporary verbal mastery. Desirable behaviors are developed by practicing them. The learner learns what he does.

4. Problem Solving

Learning activities of a problem-solving type are especially productive of the skills of critical thinking which are needed both in school subjects and in life.[16]

5. Planning

Teacher preplanning and pupil-teacher planning are both essential for well-motivated class activities. Pupil participation in planning develops pupil concern beyond the shallow aims of getting a mark or pleasing the teacher. The pupil must share if he is to care. His whole development is a matter of concern.[10]

6. Learning—A Definition

Learning is defined as the behavior changes—thinking, feeling, and acting—which result from what a pupil does.[13] Successful teaching, then, involves setting the stage—with problems, activities, and resources—that will assure the practice and attainment of the desired behavior changes.

These statements cover much research and careful thinking by many people. Coming as they do from well-recognized sources, they should be helpful in solving many problems of curriculum improvement. They become more clear as they are illustrated in practice. To provide suggestions for such practice and to present examples in operation are the purpose of this cooperative publication.

SUMMARY

1. Science education in the secondary schools has a dual purpose: to assist all youth to grow toward maturity, and to transmit and add to the racial heritage of scientific understanding and skill.

2. The two phases of science education are complementary parts of one whole problem. Psychologists agree that learning, if it is to go beyond the level of temporary memorization, must be related to the life problems and environment of the learner. Youth has a natural drive toward learning of this type.

3. Analysis of national committee reports shows a trend toward functional objectives expressed as types: "(1) functional information or facts, (2) functional concepts, (3) functional understanding of principles, (4) instrumental skills, (5) problem-solving skills, (6) attitudes, appreciations, and behaviors."

4. Functional understandings imply that the student will be able to use scientific principles in everyday life and will be able to apply them to new situations. This type of learning requires practice in learning activities which are planned for this purpose.

5. The best use of textbooks and standardized tests is as resource material along with much other material which is used in problem-solving units. A course of study may be used to assist in planning functional units which are based on: (1) scientific problems, concepts, and principles, (2) learning activities and applications, and (3) wide evaluation.

6. A functional program of science education meets the needs of all youth, including pre-college and vocational groups. A program based on principles and their use increases content mastery and provides the essential background for all students.

   These briefly summarized statements present challenges and direction for gradual and continual achievement. Suggestions for moving toward this achievement are made in the following chapters.

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CHAPTER II

ACHIEVING GREATER GOALS IN SCIENCE EDUCATION

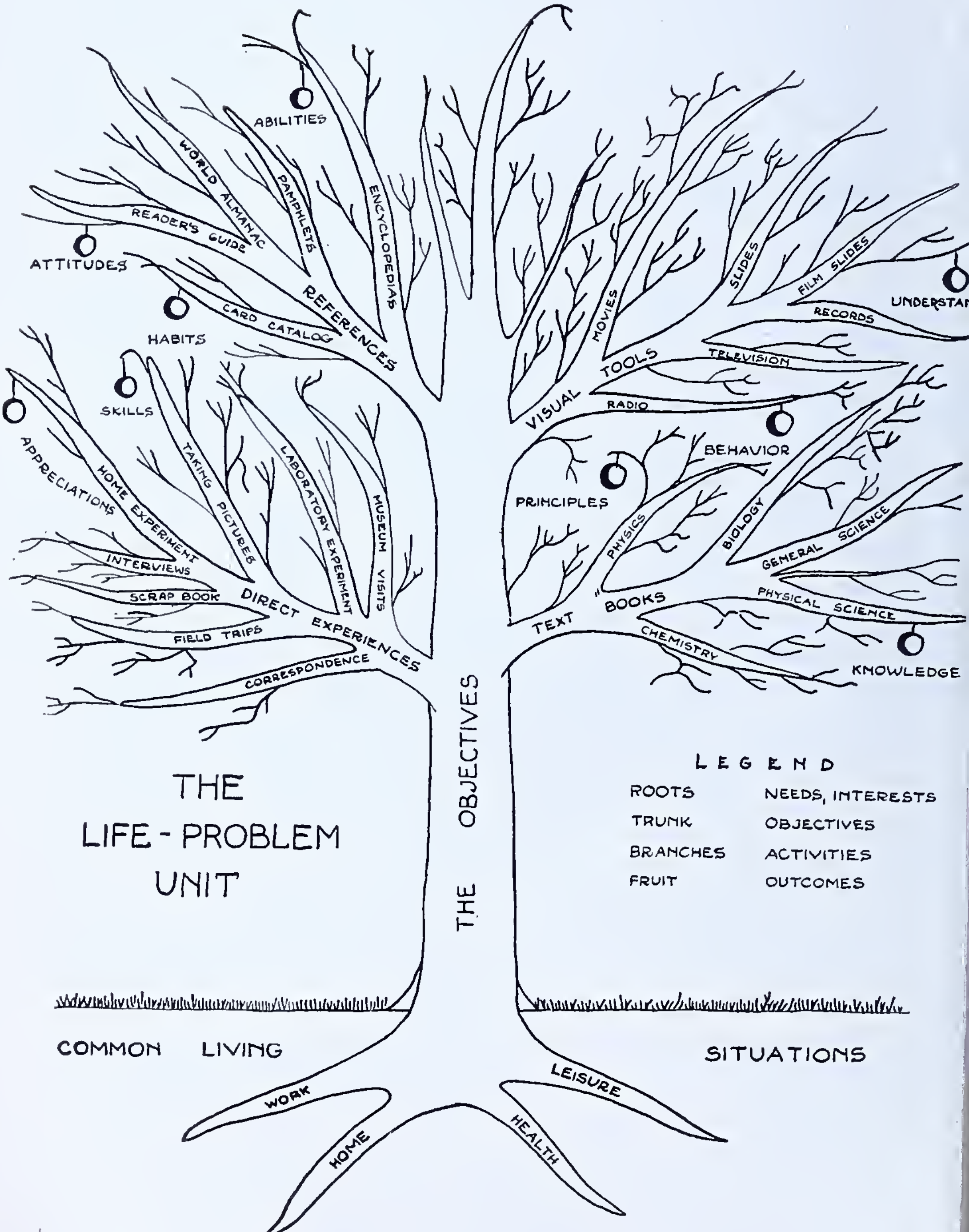
SCIENCE education becomes functional as it becomes meaningful and challenging to youth. The interaction that exists between the learner and the learning experiences which the course provides, should be considered. This determines the extent to which the science student identifies himself with the problems, understandings, and intrinsic values in the unit or course of study. Participating, as contrasted with assimilating, creates better learning and better attitudes. This basic factor is essential if the greater goals of science education are to be achieved.

The zeal which pushes the research scientist is not unlike the spontaneous drive and curiosity of adolescents. This can be encouraged or checked for youth by the learning situation. Artificial motivation or emphasis on memorization alone creates blocks against the development of scientific attitudes, inductive thinking, and the mastery of functional understandings and behaviors.

Where possible, the inductive method should be used first. Experimentation should precede drill and discussion. Real life problems should often be subjected to scientific scrutiny. There is no substitute for direct observation and direct experience. As Francis B. Haas has said: "No array of words in descriptive composition, however embellished, will serve as a substitute for actual experience."

The development of skill in planning and carrying out learning situations of this type may be a challenge to professional growth. This skill has been gained by many teachers through personal effort in planning, trying out, measuring results, and planning again. Suggestions toward the development of these and similar skills are made in this chapter under the following sections:

1. Teaching Science by Units.
2. Improving Science Teaching.
3. Meeting the Imperative Needs of Youth.
4. Teaching Students to Study Science.
5. Helping Pupils to Solve Their Vocational Problems.
6. Cooperating with Teachers of Other Subjects.


THE LIFE-PROBLEM UNIT
ABILITIES
ATTITUDES
HABITS
SKILLS
APPRECIATIONS
BEHAVIOR
KNOWLEDGE
WORLD ALMANAC
PAMPHLETS
ENCYCLOPEDIAS
READER'S GUIDE
CARD CATALOG
REFERENCES
HOME EXPERIMENT
TAKING PICTURES
LABORATORY EXPERIMENT
MUSEUM VISITS
INTERVIEWS
SCRAP BOOK
FIELD TRIPS
CORRESPONDENCE
DIRECT EXPERIENCES
MOVIES
SLIDES
FILM SLIDES
RECORDS
TELEVISION
RADIO
VISUAL TOOLS
PRINCIPLES
PHYSICS
BIOLOGY
GENERAL SCIENCE
PHYSICAL SCIENCE
CHEMISTRY
TEXT BOOKS
THE OBJECTIVES
LEGEND
ROOTS NEEDS, INTERESTS
TRUNK OBJECTIVES
BRANCHES ACTIVITIES
FRUIT OUTCOMES
COMMON LIVING SITUATIONS
WORK
HOME
LEISURE
HEALTH

SECTION 1

TEACHING SCIENCE BY UNITS

Teaching science by units is not new. Science teachers were among the first to recognize the necessity of learning *activities*. The idea of learning by doing has been the basis of laboratory science courses for many years. In adopting the unit method, other subject fields are introducing laboratory work into their courses. All teachers need to master the unit procedure for effectively guiding learning activities.

People learn naturally by whole concepts and understandings. A unit is a teaching-learning situation in which there is a "wholeness" or unity of approach in content and objectives. Wholeness is necessary for the creation of understandings or concepts. This is not provided in many courses or textbooks. The whole is greater than the sum of its parts. The parts—factual information—are of significance only as they are related to each other or to a whole problem or idea. Unless teachers can provide for this integration in functional planning and teaching, how can the pupil be expected to do it for himself in class or in life?

TYPES OF EXPERIENCES

If the emphasis is mainly on material from textbooks, a unit may be termed a SUBJECT-MATTER UNIT.[4] If the emphasis is on the learner and his needs, it may be called a LIFE-PROBLEM UNIT. Both types of units involve learning-by-doing experiences. Units are referred to by many names but are generally of these two types. In actual practice, unit teaching generally is a blending of these two if a meaningful total pattern for learning exists. The purpose of the unit determines the emphasis.

The teacher, the room, and the equipment, the ability and needs of the students are all parts of the total picture. Preliminary study of students is essential.

In order that distinctions between the subject-matter unit and the life-problem unit may be made clear, attention is called to the accompanying table of comparisons and to the "treegram" showing how the elements of the life-problem unit are related.[2]

NOTE: Superior numbers in the text material refer to Suggested Readings at the end of the section.

COMPARISON OF SUBJECT-MATTER AND LIFE-PROBLEM UNITS

Characteristics	*Subject-Matter Unit*	*Life-Problem Unit*
Organization	Logical In advance of presentation	Psychological, preplanned but also developing as unit progresses
Purpose	To acquire information	To develop understandings, attitudes, and behaviors To satisfy needs in acquiring information
Control of Learning Activities	By teacher and course of study	By entire group under guidance of teacher
Time Center	Largely in the past	Uses knowledge of the present and looks to the future
Source Material	Mainly printed matter selected by the teacher	Numerous and varied experiences determined by the entire group under the guidance of the teacher
Adaptation to Individual	Allowance may or may not be made for personal differences	Provision for personal differences
Outcomes	Fixed and planned in advance and required of all	Some outcomes are known in advance; others develop as unit progresses
Evaluation	Mostly by formal tests of subject matter	By the use of several devices in measuring pupil growth; student and group self-evaluation
Conclusion	Closed with a "review"	Interest continues to grow and leads to further activities

PLANNING AND USING UNITS

The subject-matter unit is largely a textbook presentation. Modern science texts are generally planned on the unit basis so that little re-arranging by the teacher is necessary. Topics sometimes have been termed units. This is a misnomer and should mislead no one. The method of handling such a subject-matter topic is usually the assign-study-recite-test procedure. This encourages memoriter learning.

Many of these so-called science units include no laboratory or demonstration work whatever. Both conditions should be changed. Where no laboratory or demonstration lessons can be provided, students should be encouraged to do certain home experiments, and to take field trips, such as visits to museums, depending upon the locality and its resources.

Science teachers should not only become familiar with literature on the subject but should also plan and construct experience units suitable for their own classes. Only by so doing can they hope to see the advantage of the unit method as compared with formal and traditional methods.

The life-problem unit is depicted in the treegram on page 14. The roots may be thought of as the "Imperative Needs of Youth" arising from common living situations.[1] Reading the original statement of these ten needs might be a good beginning for the unit builder. In addition to this, the teacher should learn all he possibly can by referring to the office records of his group. He may also use such a device as the "Inquiry on Student Needs."[3]

The title of the unit should be brief but adequate. "What Shall We Eat?" is a more challenging title than "Nutrition." "Does My Garden Need Lime?" is a better title for a life-problem unit than "Neutralization."

The objectives should be stated briefly and in language adolescents can understand. Student help in this process is essential. The goals set should be attainable and should be those of the student as well as those of the teacher. In addition to the central objective there may be one or more contributory objectives.

PRINCIPLES OF UNIT PLANNING

The following principles of organization are recommended:

1. Content should be organized into large areas or units (wholes), each of which represents some comprehensive scientific concept or significant problem of living.
2. Units should be broken down into smaller learning problems.
3. Learning experiences should promote functional understandings, attitudes, and changes in behavior.
4. Opportunities should be provided for discovering and applying principles inductively.
5. Provision should be made for effective evaluation—including self-evaluation.
6. Sequence should be planned to give recurrent contacts with knowledge and to provide a spiraling and enlarging pattern of growth.
7. Problem situations should provide practice in the use of the scientific method.
8. There should be frequent opportunity for pupils to participate in planning.

The dynamics of putting into practice these recommendations of the National Society for the Study of Education are presented in the following outlines:

Procedures in Unit Planning

In planning and using a unit, six stages are usually followed:

1. *Selection of a title covering a critical life problem or scientific concept*
2. *Preplanning by the teacher*
   a. This includes (1) objectives, (2) content, (3) sources, (4) activities, (5) evaluation.
   b. Teacher planning is frequently kept in the teacher's mind and the pupils are invited to plan. Enriched meaningful planning results

and includes the teacher's suggestions which are based on his own preplanning.

3. *Orientation—Introduction of the Unit*

Group discussion provides a good way. Pertinent questions are:

What is our problem? These are
What do we know about this now? steps in
What do we need to find out? scientific
How can we find out? How can we organize? inductive
How can we tell if we do find out? reasonin

This provides an overview of the unit, relates it to past experience, suggests phases for consideration, develops a work plan, and organizes work groups.

Possible activities in this phase include: school trips, excursions, pictures, news items, talks by teacher, etc.

4. *Pupil Learning-by-Doing*

Pupils practice the behaviors of analyzing, applying, comparing, constructing, discussing, evaluating, generalizing, interviewing, leading, observing, organizing, outlining, studying, thinking, summarizing, etc. Many class periods are devoted to group work under teacher guidance.

The objectives (in 2 a. above) should provide a check list for the activities. No objectives should be left dangling. There should be learning activities for each one.

Students can acquire the understandings or behaviors, which are stated in the objectives, only by having learning experiences for their development.

The teacher circulates among the work groups. He provides guidance, makes suggestions, supervises leadership and group dynamics. He may call the total class together from time to time for progress reports.

5. *Culminating Activity*

Here pupil reports, panel discussions, demonstrations, exhibits, graphs, models, projects provide expressions of group and individual achievement. Students frequently keep notebooks to record the results of the total classwork. These are the fruits on the treegram, page 14.

This activity may well include some form of social action, such as tree planting, restaurant inspection, health surveys, etc., depending upon the community.

6. *Evaluation*

Pupils and teacher together may well consider the following questions:

a. Was the unit worth while from the standpoint of content mastery? (test)

b. Have the understandings, attitudes, and behaviors—which were stated in the objectives—been attained? Each objective should be evaluated.

c. Have pupils gained in the ability to analyze, apply, compare, generalize, and use resource material?

d. Did the group process work well? Are pupils more cooperative, less ego-centered, more self-confident?

e. What need exists for drill, direct textbook teaching, or reteaching?

Dangers to Be Avoided by the Teacher

1. Exercise of too much authority. This destroys pupil initiative and spontaneity.
2. Too much haste. The democratic process is slow but sure.
3. Too much laissez-faire action. Democracy is neither autocratic nor laissez faire.

SAMPLE UNIT PLAN

The transition toward more vital and functional learning, as a teacher participates in a program of curriculum improvement, is indicated in the following unit plan. This teacher's plan shows what happened as he learned to make use of direct learning experiences.

THE OLD	THE NEW
Topic: Fish	Topic: How does Fishing Influence Our Living?
Objectives	Objectives
Teacher:	*Teacher:*
To cover the topic as described in the General Science Syllabus	To make children aware of the relation of fish to themselves To create a desire to learn more of the natural world To set up experiences which give children a chance to work and play together To use group processes To offer challenges to bright pupils To help nonreaders to contribute to group work and find other ways of learning and of expressing themselves To increase children's interest in and enjoyment of school.
Pupils:	*Pupils:* (Group planning)
To do the lessons assigned by the teacher to get good marks	To practice good human relations in the class To improve skills and abilities To have fun To learn facts To begin a new hobby
Content:	*Content:*
1. Characteristics of fish 2. Classification 3. Structure 4. Uses to mankind	Same

THE OLD

Activities:

1. Put week's assignment on board
2. Make large diagram of fish on board
3. Present the topic and label the diagram
4. Show some pictures of fish
5. Read and discuss texts with class daily as preparation for home assignments
6. Conduct class recitations on home assignments

Culminating activities:
None

Evaluation:

1. Give, mark, return tests
2. Reteach facts not known
3. Give another test to those who failed

THE NEW

Activities:

Group planning for individual and committee activities and reports to accomplish the following:

1. Provide for research as many books on fish as can be obtained
2. Secure and display around room colored pictures of fish (motivation)
3. Secure and show films on tropical fish, deep sea diving, fishing industry
4. Secure large biological model of fish
5. Arrange for demonstration dissection of either raw or cooked fish
6. Contact Home Economics Department and arrange for fish luncheon (teach etiquette)
7. Investigate possibility of trip to an aquarium or hatchery (teach techniques of planning—teach proper conduct in public vehicles)
8. Secure paper, paints, crayons, and arrange for art teacher as consultant for art work
9. Investigate possibility of Saturday hike where fishing can be done (good human relations—leisure time activities—planning—responsibility)
10. Arrange with local sports store for demonstration of fishing tackle, bait, flies, etc. (teach good sportsmanship, leisure time activities)
11. Consider possibility of having someone teach interested group to make artificial flies (letter of invitation and thanks)
12. Get clay, soap, tools for carving and modeling (permit some of this while research reading is being done)
13. Suggest and assist pupils to secure, furnish, care for an aquarium (teach principles of balance in life—good activity for non-readers)
14. Find a tropical fish enthusiast and arrange for talk on and display of them (teach reproduction)
15. Stimulate interest of brighter pupils in making scientific investigation, developing booklets, developing reference lists, hunting up classification, accumulating clipping files, sending for free and inexpensive materials
16. Don't forget keeping of records of all kinds by everyone

Culminating activities:
Committee reports, displays, and individual records

Evaluation:

1. Arrange for tests of facts learned
2. Have group discussion of strengths and weaknesses of planning committee work, committee leaders, behavior on trips, learning experiences, development of interests, skills, abilities
3. What drill and formal instruction are needed?

SCIENCE TEACHING SHOULD BE SCIENTIFIC

Science teachers should recognize the need for research in teaching and learning. They should be willing to use and to master the unit method or any other promising method. Unit planning includes the elements of good teaching. Every craftsman should possess all the skills which he needs for his task.

A cleavage exists in secondary schools. Probably not over one-tenth of the students go to college. The others terminate their education in high school. It is clearly the job of the teacher to reach both groups. *The college-bound student should have the opportunity to obtain the very best preparation for his college needs.* As far as science is concerned, many of the colleges expect their entering students to be well prepared in the information associated with subject-matter areas. Individual research should be undertaken by each teacher to find out to what extent he can equal or exceed normal, so-called subject mastery through *functional* teaching.

Unit study by subgrouping in work committees provides for students of all types. With the academic students an enriched and functional subject-matter approach may be the more suitable. These students especially should practice the understandings, attitudes, and skills necessary for planning and independent study. As many activities as possible should be provided for them. In other words, the subject-matter unit should be enriched as much as possible.

With the students who terminate their formal education in high school the life-problem approach is a definite answer. With this group much more can be accomplished by any teacher with the wider use of student participation than by an information-centered approach.

Dividing the year's work into both generalized and specialized approaches has great possibilities for (1) life-centered understanding, (2) youth-centered problem-solving, and (3) mastery of information. However, much depends upon what the teacher himself is able to do.

SUMMARY

1. The unit method of teaching has definite advantages.
2. The type of unit used will depend upon the nature of the learning group, the facilities of the school, and the community resources.
3. The unit method, like any other, is a means to an end. Unit teaching should, however, help the science teacher in preparing youth to appreciate and use the scientific method and to understand the main facts and principles concerning the universe, the world, and man.
4. For a synthesis of informational material into understandings, wholeness in organization is essential.

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SECTION 2

IMPROVING SCIENCE TEACHING

"We want to know how to deviate from the textbook without getting lost; how to introduce and teach a unit; how to plan with pupils. . . ."

"We want to know how to change the morale and behavior of groups; how to use the principles of group dynamics; how to help groups reach decisions and evaluate their own work; how to relate on-going activity to the problems, concerns, and tensions of pupils; how to work with a small group in a classroom and, at the same time, keep other pupils profitably busy. . . ."

"We want to know how to spot and use community resources; how to find people who know the answers to our problems and how to get their help; how to build units on problems not found in textbooks; how to provide school experiences that will help pupils toward maturity."

These are typical of the replies of three hundred classroom teachers to an inquiry on what help they wanted most.[6]

Similar "know how" problems are faced by many teachers today. They have been created by the impact of modern education upon an ancient educational process. Statistics which reveal startling personal and social shortages have made their solution a matter of deep concern. Their consideration by school faculties and individual teachers is challenged; for their solution, experimentation must move into the classroom.[4]

For a long time, the research pattern used in education has been based upon the methods which have developed progress in the physical sciences. Controlled statistical experimentation has established the validity of many educational principles. Because of this, the knowledge of what education can and should do has far outrun its practices. The research

value of reports which are filled with statistical jargon is generally incomplete because the classroom application is not accomplished.

Reports in this bulletin indicate how individuals have solved the *how to* problems which teachers present. The results as reported make evident the factors of the situation which produced them—the teacher, the pupils, the school, and the equipment. They provide stimulation and suggestions. Yet, *bulletins and reports are of significance not in what they do for people, but in what they get people to do for themselves.* Each teacher should, through experimentation, try out and reconstruct the experiences of others, in his own classroom, if *how to* problems are to be solved.

First attempts may not achieve full success. As in any kind of problem-solving, learning-by-doing—particularly learning-by-trying—is the best approach. Few experiments in education end in failure. There may be much room for improvement; the zeal, vigor, and enthusiasm which the experimenter himself contributes result in better total development of students no matter what probable results may be measured.[1]

Some directions for self-improvement by a teacher are indicated in the self-rating chart on page 24.

Achieving Objectives

When a school faculty, a faculty committee, or an individual teacher decides upon objectives to be achieved, materials for a direct attack upon the objectives are prepared. These materials usually take the form of (1) improved lesson plans or topical content units which show lateral enrichment—content, objectives, learning activities, and enriched means of evaluation—entered on a flow chart, or (2) problem-solving or other units for which the objectives, or phases of them, are unit titles and bases for planning.

Experimentation is necessary in the tryout and evaluation of new materials and methods.

Another kind of classroom experimentation is the "piecemeal" type. Problems considered are those that arise out of the local situation and seem of importance to teachers. This problem-solving is constantly underway with many teachers to whom improvement in any of the many day-by-day ways of teaching is a constant challenge. As a type of informal research, it is of great value. Its steps may be described by such simple things as: (1) *an idea that something can be done better,* (2) *a tryout of what seems better,* (3) *some data are gathered,* (4) *judgment is used to measure improvement,* (5) *more know-how and professional satisfaction result.* This action-research can be carried on by every teacher. Without it curriculum improvement is not possible.[2]

A TEACHER'S SELF-RATING CHART

	CHECK		
	Yes	?	*No*
1. Can I depart from daily recitation (textbook assign-study-recite-quiz procedure) without getting lost?			
2. Can I plan and guide an experience *subject matter* unit?			
3. Can I plan with pupils and guide an experience *life-problem* unit?			
4. Do I know how to use the principles of group dynamics?			
5. Do my pupils feel free to discuss their problems with me?			
6. Can I relate content teaching to the adolescent problems, concerns, and tensions of pupils?			
7. Can I subgroup, form committees, etc., and keep all working on a well-motivated level?			
8. Do I know how to spot and use community resources?			
9. Do my students apply the principles of my subject to their own problems?			
10. Do I involve the introverted and "isolates" in group activities?			
11. Do I teach my pupils how to read and study my subject?			
12. Do my students use good English in oral and written reports?			
13. Do I continually invite student problems for discussion and problem-solving?			
14. Are my students having actual, frequent practice in critical, inductive reasoning?			
15. Do I work with a club to further special interests?			
16. Can I define the actual pupil behaviors—thinking, feeling, and acting—which I am trying to develop?			
17. Do I guide learning activities in which desirable behaviors are practiced?			
18. Have I had adequate preparation in fields which are related to my subject?			
19. Do I have an adequate knowledge of my object—the learner?			
20. Have I had intensive and modern preparation in the subject I teach?			
21. Do I relate my work to that of other subject teachers in my school and request similar cooperation?			
22. Do my students understand the vocational opportunities in my subject field or work to which it may lead?			
23. Do I praise more often than I blame?			
24. Do I subgroup to meet the special needs of vocational and precollege students?			
25. Do I make a special effort to locate and encourage talented youth?			

Obstacles to Action Research by Teachers

Secondary-school teachers and principals must be free to try out better methods and materials without threats to their security. Otherwise, the status quo will not be disturbed. Individual initiative will be a lost virtue.[4]

Administrative encouragement and time and materials promote faculty and individual teacher action research.

REVIEW OF RECENT RESEARCH IN SCIENCE EDUCATION

The Implications of Recent Research in the Teaching of Science at the Secondary School Level

This summary[7] reviews research in science education during the period 1940-1948. The following are the most significant items:

1. Certain concepts cannot be developed satisfactorily with younger students. Proper grade placement of all important concepts should be made.

2. Many studies place emphasis upon the practical aspects of science programs—water supply, food, conservation, consumer education, health. The teaching of formal science may be made more practical and longer remembered by such integration.

3. An integrated sequence of general science for the 7th, 8th, and 9th grades is the most desirable program for the junior high school. Most schools offer only general science at the 9th grade. Students who have had general science throughout the junior high school show superiority in later courses in science over students who have not.

4. The increasing development of integrated courses in physical science is significant.
   a. Two researches show that students taking fused courses in physical science for one year perform better on tests in physics and chemistry than do students who take either physics or chemistry.
   b. The Forty-sixth Yearbook[8] stresses the value of physical science for both college and noncollege-entrance students.
   c. The majority of teachers consider physical science of more value than physics or chemistry for noncollege-entrance students.

5. Vocabularies are generally too difficult in textbooks. More applied science is being included in current texts. Some texts present problem materials in a way that promotes thinking.

6. If attitudes are objectives, they should be taught directly since the mere study of science does not make a unique contribution. Marked improvement is evidenced in scientific thinking when specific attention is given to obtaining this outcome.

7. There is a definite need for more direct teaching and testing for the understanding of principles and for the development of scientific attitudes and skills.

8. For superior students the unit plan was found to be significantly better. No method is superior for all topics or for all students for subject mastery. A good teacher should be the master of all tools and techniques which he needs.

9. An investigation of the effect of the study of chemistry in high school upon college marks favored those who had chemistry in high school, but the results were not significant.

10. Studies indicate that, in general, teachers of science in high schools are not so well trained as might be desired.

SUMMARY

1. Modern education and social tensions have brought critical problems to teachers. These are revealed in surveys of teacher problems.

2. The failure of an inherited secondary-school program which is based on mastery of information to meet modern educational demands has created the need for more vigorous and dynamic types of teaching.

3. Teachers' problems are best solved by cooperative action of the total faculty or of a faculty committee. Experimentation is a necessary phase for the tryout and evaluation of results.

4. Grass-roots action research should be a constant procedure in schools where the use of teacher initiative is valued and recognized.

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SECTION 3

MEETING THE IMPERATIVE NEEDS OF YOUTH

MEETING YOUTH NEEDS [1]

The following list of pupil needs and the manner in which science can contribute to meeting them was compiled by a committee of teachers from the Northwestern District of the Pennsylvania State Education Association in cooperation with pupil committees. Although the list is not exhaustive, it is evidence that science education can contribute to meeting the needs of youth for life adjustment.

CONTRIBUTIONS OF SCIENCE TO PUPIL-NEEDS

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
1. Skills, understandings, and attitudes that make the worker an intelligent and productive participant in economic life	
a. Scientific understandings to help in choosing a vocation	a. The exploration of the various subject areas in science provides an insight into occupations and interests. Field trips to industrial plants and laboratories
b. Carefulness, neatness, and precision	b. Laboratory experience, proper form in making reports, etc.
c. Recognition of the importance of an honest achievement on the pupil's level and the limit of his ability	c. The report of a laboratory experiment performed by the pupil and written up as a report of his own efforts with correct deductions and conclusions is an excellent motivating device to accomplish attainment of this understanding
d. Proper method of pouring liquid from bottles, handling of stoppers, correct methods in measuring, practicing safety factors	d. Constant practice in laboratory exercises
2. All youth need to develop and maintain good health and physical fitness	
a. Knowledge that certain discomforts, shortages, and physical ills are not necessary in a scientific society	a. The study of foods as to nutritive value and vitamin content; how each contributes to the growth, development, and

[1] See Bulletin 243, *Curriculum Improvement by a Secondary School Faculty*, Department of Public Instruction.

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
	maintenance of certain parts of the body and nervous system. Discovery and research in the field of medicine bring newer methods and materials to produce a desired effect. Research is providing substitutes for natural products which are becoming scarce and expensive; new alloys lighter and stronger, etc.
b. Functional knowledge of community health and safety; higher living standards	b. Study of the subject areas of sanitation, food inspection and grading, pure food laws, industrial processes used in the community
3. Knowledge and practice of the rights and duties of a citizen in a democratic society; as a member of the community, and as a citizen of the State and Nation	
a. To develop standards which will make for desirable civic and social outlook	a. Opportunity to practice such standards through group participation in the science laboratory and classroom. The consequences of poor standards
b. Knowledge and practice of democratic processes, the acceptance of authority and responsibility	b. Laboratory work by pupils working in groups and a consideration of the history and development of modern science lend themselves admirably to development of democratic processes and acceptance of responsibility
c. An understanding that property rights, human rights and privileges must be respected in harmonious social living (This understanding also contributes to satisfying need under item 4)	c. The practice of students working in groups, classes working together on a single problem, groups working together in the laboratory, for all of which properties and supplies are issued, can be made a tool for practicing this understanding

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
4. Understanding the significance of the family to the individual and to society and the conditions conducive to successful family life	
a. Application of biological facts and laws of physical science to present-day life situations	a. The study of these subject areas should provide opportunity for relating them to present-day life situations
b. Sex education	b. The study of reproduction, personal health and hygiene, family relationships and laws of heredity, all contribute to meeting this need
c. Ability to handle controversial issues	c. Consideration as a group of such subjects as the development and means of control of atomic energy and atomic weapons; acting as chairman of class committee considering history of the development and acceptance of certain laws in science, etc.
d. Ability to participate in group processes and cooperative activities	d. No subject offers greater or wider possibilities. Development of cooperative planning and execution of science units involving laboratory solutions of problems is ideal for group learning experiences. Committee and group programs can be utilized
e. A sense of right and wrong —i. e., moral and spiritual values	e. Laboratory work in science can be made an ideal tool with which to develop this trait
5. All youth need to know how to purchase and use goods and services intelligently, understanding both the value received by the consumer and the economic consequences of their acts	

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
a. Ability to make wise choices	a. Practice in use of the scientific method
b. Consumer education	b. Can be interwoven through all science subjects by emphasis on such subjects as grading of materials, cost of production, natural resources and supply of raw materials, synthetic products and substitutes, laboratory analysis, reports on consumer research
c. The practice of general economy in use of materials and energy	c. Laboratory processes show that in general, desired results can be obtained only with exact amounts of materials and supplies as recommended and that variations in these amounts obscure the desired result and produce misleading observations. Use of small amounts is often better than use of large amounts in observing a stated chemical change or process. Commercial chemical processes show the value of economical use of materials. This same economy in use of materials can be carried over into general life situations
d. Knowledge leading to wise selection, use, and conservation of family resources, such as food, clothing, housing, home furnishings, home equipment	d. Study of foods in biology and chemistry; textiles in general science and chemistry; building materials and their properties in chemistry and physics; machines used in the home in physics, etc.
e. Care in handling and manipulating precision tools and instruments	e. Instruction and practice in the use of balances, meters, measuring instruments
f. Conservation of human and natural resources	f. Laws of health; knowledge of uses and sources of natural raw materials with consideration to probable supply; methods of conservation

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
g. Functional knowledge of merchandise	g. Knowledge of sources of various articles of merchandise; tests for various fabrics and textiles and for authenticity of goods
h. Realization that one never gets something for nothing in the physical universe	h. Applications in physics and chemistry thoroughly meet the concept that everything must be paid for
6. All youth need to understand the scientific method, the influence of science on human life, and the main scientific facts concerning the nature of the world (universe), and of man	
a. Understanding scientific problems	a. Through consideration of agricultural problems of crop feeding, selection, and production; industrial problems based upon scientific inventions which involve change in labor supply and demand; community problems involving scientific changes, such as water supply, sewage disposal, power supply, etc.
b. Understanding life today with recognition of events in the past and their bearing on present-day living	b. Discoveries and inventions in science have had and are having a profound influence on present-day living
c. Substitution of scientific fact for superstition and traditional beliefs	c. Through the acquisition of knowledge of natural laws and scientific principles, an understanding of the true explanation can take place
d. Use of scientific methods in place of the uncontrolled, biased, and fragmentary methods	d. Constant training in the application of the scientific method in laboratory exercises and reports
e. Knowledge of natural environment and phenomena and their effect on life and culture of the community,	e. Since this is one of the primary objectives of science education, it is accomplished through a knowledge of: natural laws and

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
the nation, and the peoples of the world	their application; natural growth and development in the animal, vegetable, and mineral kingdoms; soil erosion and conservation; laws of heredity; climate; etc.
f. Appreciation of the close relationships between scientific knowledge and achievement and human welfare, industrial progress, and economic trends	f. A consideration of the work necessary to build a new industrial plant; emphasis on sociological implication of discoveries and inventions in science, medicine; safety factors, transportation, communication, etc.
g. Elementary knowledge of the construction and use of machines used in the home	g. Physics and general science furnish excellent opportunity to gain a workable knowledge in this area. This is an appropriate area for Physical Science for 11th or 12th grade
h. Knowledge of the sources of electric power and uses of electricity (Also see 5, f and h)	h. General science and physics will supply this need
7. All youth need opportunities to develop their capacities to appreciate beauty in literature, art, music, and nature	
a. Accuracy and alertness in observation	a. Through individual laboratory work in which the solution depends upon the individual and on him alone
b. Appreciation of the relation of science to cultural life	b. Through attention to the effect on our culture of discoveries and inventions, and new applications of science principles. These have given us radio, television, modern methods of transportation, new fabrics and textiles, all of which have changed our standards of living and of recreation. Science abounds with material to ac-

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
	complish this need. Also through consideration of the work of noted scientists, their methods of work, their achievements, and the effect of their work on human life and culture
c. Applications of principles of color and light	c. Physics presents these principles and opportunities to learn their application
d. Application of the principles of sound	d. Physics presents these principles and opportunities to practice their application
e. Appreciation of the biological principles involved in the selection and preservation of species in nature	e. Biology and chemistry both contribute much to satisfy this need—protective coloring, fall coloring in leaves of deciduous trees, etc.
8. All youth need to be able to use their leisure time well and to budget it wisely, balancing activities that yield satisfactions to the individual with those that are socially useful	
a. How to spend leisure time	a. Various phases of science often provide the individual with an interest and incentive for hobbies; e. g., photography, hydroponics, radio. Science clubs form excellent media for stimulating hobbies
9. All youth need to develop respect for other persons, to grow in their insight into ethical values and principles, and to be able to live and work cooperatively with others	
a. Respect for the dignity of common labor	a. Consideration of the work phases necessary to completion of various industrial processes will show the necessity for all types of labor, each making

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
	valuable contribution to the whole, without which the process could not be brought to fruition
b. Tolerance for opposing viewpoints and opinions, and for others with lesser abilities in certain areas of living	b. Study of the history of science and biographies of noted scientists; group participation in solving problems
c. Respect for integrity and a desire for truth	c. Study of the history of solutions of various specific scientific problems, e. g., the conquest of yellow fever in the Canal Zone; specifics in medicine and drugs. Individual laboratory work in solving assigned problems. Biographies of nóted men in science and their search after truth
(See also 4 c, d, and e)	
10. All youth need to grow in their ability to think rationally, to express their thoughts clearly, and to read and listen with understanding	
a. Ability to read and interpret the printed page accurately	a. The study of science provides a new vocabulary and a new field for reading. Accuracy of interpretation is necessary
b. Carefulness and correctness in the use of words—accuracy of statement	b. The study of science provides an active speaking vocabulary and teaches that a careful choice of words must be made in expressing scientific laws and principles
c. Exactness in written expression	c. Reports on laboratory exercises and testing programs demand exactness and accuracy in expression
d. Exactness in oral expression	d. Giving oral reports on research, stating scientific principles and laws, reports on laboratory observations, trips, and interviews

NEEDS	HOW MET THROUGH SCIENCE EDUCATION
e. Ability to listen effectively	e. Listening to reports of student groups on phases of cooperative work and reporting on same Listening to instructions which are given but once
f. How to tell fact from fancy in advertising claims: propaganda analysis	f. Knowledge of various tests which can be made and of the actual materials and their properties used in the manufacture of the advertised merchandise
g. Ability to reason from observed phenomena to the general principles involved	g. Laboratory work aims at developing this habit, i. e., the scientific attitude of forming logical conclusions from established facts and principles
h. Effective habits of thought	h. Development of a logical conclusion from observed facts in laboratory work, in reading and research, through correct testing techniques
i. Knowledge of a diversity of scientific terms and their meanings adequate for reading magazine and newspaper articles with understanding and appreciation (See also 4c)	i. Attainment of an adequate scientific vocabulary

SECTION 4

TEACHING STUDENTS TO STUDY SCIENCE

Much has been written concerning the need for the study habits and skills which are necessary for efficient learning. Such treatises usually deal with methods of study in general and do not treat particular subjects. However, every subject teacher is responsible for the development of both the general and specific reading skills which his students need.

Much that has been written applies to other subjects as well as to science. The first part of this discussion reviews some suggestions for study that apply to all subjects. Later, some suggestions are made that apply more specifically to the field of science.

HOW TO STUDY

A Definite Time and Place

The first step in formulating a plan of study is to establish a schedule for study. The school program provides a definite time and place for each subject. *The individual student should be encouraged to find a definite time and place for study out of class.* Few subjects can be mastered without some attention outside the classroom. It should be pointed out to the student that dependence upon unscheduled free time for study usually results in no study whatever. Likewise a good student will find a place to study where he will not be disturbed. Here he will read his assignments, review, formulate questions on which he needs help, or do whatever is necessary to fulfill his obligations to the course. The time allotted need not be great, but it should be scheduled, and the schedule kept.

Reading Difficulties

Since preparation for classwork may be reading, the teacher and the student should make a frank appraisal of the student's reading ability. Many students do not learn as much from reading as they should. Many are just lazy readers. Others are not book-minded. *Instructors should be on the alert to help poor readers become better readers.* Although some schools have remedial programs designed to help students who are low in general reading ability, much can be done by the science teacher himself.

Research shows that a preliminary overview of the written material, followed by a close study with note-taking, results in best comprehension. Preparation of questions or the study of questions at the end of the chapter before reading has been found helpful. Reading to find the answers to questions is very productive. The pupil should also acquire by practice, with the instructor's help, the ability to make outlines. Merely assigning work without suggesting ways to attack it is not enough.

The science teacher should have available many popular books and magazines on science. The students' recreational reading can be used to provide strong motivation for more serious study. In addition, abundant resource material to supplement the textbook should be available in a classroom library.

Seeing is the best way for some students to learn; for others, hearing and listening are best; and for still others, handling objects. Many learn best by a combination of all three.[8] Hence, there is a need to combine all approaches, and, at the same time, to give opportunities for each student to learn in the way or ways most suited to him. The book-minded, the hand-minded, and the audio-visual-minded, all must learn. Experience units provide learning activities of all types.

SOME STUDENTS LEARN BY HANDLING OBJECTS

Development of Reading Skills

For most students, reading is a universal way of learning. Any teacher has it in his power to improve student performance in this respect by the following procedure:

1. Have all students read a page or pages of material for one minute, starting and stopping on signal. The stopping place is marked.
2. Uncover on a blackboard five or ten comprehension questions concerning the material which has been read. These require of each pupil answers on paper.
3. The correct answers to the comprehension questions are provided.
4. Each pupil marks his own paper on comprehension and counts the number of words he read in one minute.
5. List the number of words read by each pupil. Find the mean or median. List the number of questions answered by each pupil. Find the mean or median.
6. Each pupil studies his own standing with respect to his fellows.

7. Graph-keeping by individual students of weekly exercises of this type indicates deficiencies, promotes self-appraisal and practice, and improves the student's reading ability, unless actual psychological difficulties exist that require a specialist.

Research on Reading Skills

Recent research on reading provides the following conclusions:

1. There exists a high degree of specificity in the factors relating to reading in a specific subject area.[1]

2. Diseases or defects are 21.2 per cent more frequent among reading failures.[3]

3. The subnormal boy may be a keen reader with a critical attitude.[4]

4. Easy material has short sentences with a high proportion of common words.[6]

5. Shorter words and sentences make for increased comprehensibility.[6]

6. Superior college students are not uniformly efficient readers. Less than half read faster than 325 words per minute.[9]

7. There are factors, in addition to reading competence, essential for success in study activities.[9]

8. Many textbooks are more difficult in reading than their grade placement.[10]

9. Children need help in reading diagrams.[7]

10. There seems to be no doubt that the task of mastering the vocabulary peculiar to chemistry is beyond what reasonably ought to be expected of a high school student. Much of the difficulty of chemistry and other sciences is verbal in character.[5]

11. Students forget because more emphasis is placed on information than upon the application of facts and principles in solving problems.[5]

Developing Student Interest and Effort

Teachers of all subjects agree that little can be learned without an interest in the material to be studied on the part of the student. An interest is a fusion of pupil needs. Good instructors spend considerable time in developing an interest by focusing or basing the learning experiences on instinctive psychobiological pupil needs and problems. The instructor must have a deep interest in the subject and in the student himself, if he expects the student to become interested.

Many needs are acquired. The teacher should provide leads as well as meet needs. Few fields of human endeavor are devoid of interesting possibilities. Ways of developing pupil interest are: (1) class trips, (2) talks by scientists in the community, (3) science clubs, (4) popular reading in the science field, and (5) vocational emphasis.

The science instructor should strive to present material so pertinent to the needs of young people in learning-by-doing situations that such artificial aids as memorizing and cramming are unnecessary. Information that is used in and out of the classroom soon becomes the possession of the learner. This ideal of learning may be approached by unremitting attention to the real problems of youth.

Drill and Review

Review for examination is necessary. Many instructors provide time for drill and review as need arises during regular unit study. Reviewing concepts, principles, factual data and applications for examinations is not to be confused with "cramming" wherein the student attempts to learn at one sitting material that should have been learned over a period of several weeks or months. There should be frequent review of basic concepts in subjects and units that have been studied.

HOW TO STUDY SCIENCE

Special procedures in learning science are derived largely from the emphasis of science on "thing learning." Scientists are willing to accept authoritative information tentatively, but they turn to nature's objects themselves for final confirmation. In many cases of learning this is not possible, but it is the very lifeblood of the science program. The laboratory is the citadel of the scientist. It is in the laboratory that he puts the objects to the test.

Laboratory Work

Students studying science learn to realize that the purpose of the laboratory is for the learner to discover truths from the objects that surround him and to confirm or reject facts presented by others. In some cases it is better to have the instructor or selected students do the actual experiment. At other times individual students, pairs, or groups of students should work together on an experiment. *Inductive research should precede and be supplemented by book study.* Many important discoveries have been made by alert students who believed the evidence of their own eyes rather than that of the person who wrote the book. The questioning attitude should be encouraged.

Students might well be encouraged to set up their own experiments to check what seems to them to be the truth. The necessity of controls should be carefully developed. Students are apt to draw conclusions from the results of one trial when a control would show that the same results might not follow under other conditions.

Scientists use the outdoors as a laboratory as well as the indoors in seeking for new truths. The secondary student seeking to understand science should be encouraged to do likewise. Important truths may be discovered with simple materials and equipment.

Developing Skill in Measurement

Scientists have found it necessary to measure things. Therefore some of the work in the laboratory will deal with measuring such things as sizes and weights of objects, speeds of moving objects, and temperatures. These measurements must be done carefully, repeated, and averaged in order to detect important differences. Students not accustomed to measuring things precisely must learn to do so or the results of their experiments will not be worth anything. Instructors must be patient but insistent on careful measurements.

Scientists have found the metric system of measurements much more suitable than other systems of measurement. The metric system is based on the decimal system, and once mastered has many advantages. The best way to master the metric system is to *use* it in the laboratory and in everyday life. Quick memorizing results in quick forgetting.

Mastering the Vocabulary of Science

Many students find it very difficult to learn the new names connected with the various fields of science. Many of these terms are unavoidable, such as the names of the elements. In the life sciences, many names are derived from Latin, and students are prone to rebel at learning such names.

Teachers must be skillful indeed to introduce necessary technical language slowly enough so that students will learn to use it. With use will come familiarity. If the terms are not to be used, there is no excuse for learning them. Instructors must be sympathetic with the student's conditioning against technical terms since some of the conditioning was done by adults, even by teachers. Explanations of the meaning of words, explanations of the reasons for such terms, accompanied by an honest effort to reduce the difficult terminology to those that will actually be used by the majority of the students, will go far to eliminate the mind-set against the introduction of new words in the science class.

Use of Inductive Reasoning

Students should be encouraged to use scientific methods outside the science class. Students should constantly ask such questions as: Where did you get your information?—What is your evidence?—Did you see it happen?—Were you there when it happened?—What is your authority for such a statement?—Is your source of information reliable?—Who was the author of the book that you quoted?

Careful thinkers admonish us to say, "I believe this to be true" or "The evidence points this way." People who know little may be positive in

their assertions, but the learned scientist will usually speak more humbly. Students should have many opportunities to practice such thinking. Perhaps the most fruitful method of teaching a high regard for truth is for the instructor to employ such practices and to have such a regard in his everyday work with the students of the secondary schools.

SUMMARY

1. Every subject teacher is responsible for the development of the general and special study skills of his pupils.
2. General study skills involve: (1) a regular time and place, (2) general reading abilities, (3) developing student interest and effort, and (4) drill and review.
3. Specific study skills in science include: (1) skill in laboratory work and observation, (2) skill in measurement, (3) reading skills, (4) vocabulary mastery, and (5) the use of inductive reasoning.
4. There is much that every science teacher can do to improve the reading of his students. Assigning and hearing lessons is not enough. Simple drills and measurements achieve significant progress.
5. Teaching which emphasizes mastery of information, rather than principles and their applications, contributes to low retention. Facts, understandings, attitudes, and behaviors are taught most economically and effectively when they develop—through use—in group and individual problem-solving.

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SECTION 5

HELPING YOUTH TO SOLVE THEIR VOCATIONAL PROBLEMS

One of the greatest concerns of youth is that of finding a suitable life work. In this area the science teacher has a great opportunity. Many hundreds of types of occupations require scientific skills. It is the responsibility of every science teacher to point out where opportunities exist. This is especially true for the science-talented youth.

Educators today have widely accepted the fact that all good teachers are guidance-minded. The students who are in science classes should acquire not only subject matter, but also many personality factors, and much vocational information and career guidance. This guidance has much merit where good teachers can establish rapport by displaying interest in the total welfare of their students. The subject teacher in this situation can exert an inspirational influence greater than that of many guidance specialists.

Present-day living and the world in which future generations will exist is and will be increasingly scientific. Science teachers should keep abreast of the vocational trends in scientific occupations. They should be cognizant of some of the general requirements to be met in the more popular scientific vocations.

The selection of a suitable lifework should be a process in which the relationship of abilities, interests, and personality factors is carefully considered. A properly chosen vocation can bring about satisfactions to the individual in three ways:

1. Physical well-being, using up mental and physical energy
2. Ego-satisfaction
3. Social acceptability, developed through extroverted living

A balance among these three must exist throughout a person's entire life if he is to be a constructive, productive, efficient worker. This balance is possible only if an employe achieves it in a satisfying vocation suited to his particular make-up.

Classification of Occupations

Thousands of occupations are listed and defined under the following headings in the *Dictionary of Occupational Titles,* published by the U. S. Department of Labor. It can be secured from the Superintendent of Documents, Washington, D. C.

		D. O. T. Code No.
0	Professional and Managerial	
	Professional	0-00 through 0-39
	Semiprofessional	0-40 through 0-69
	Managerial and Official	0-70 through 0-99
1	Clerical and Sales	1-00 through 1-99
2	Service	
	Domestic Service	2-00 through 2-19
	Personal Service	2-20 through 2-59
	Protective Service	2-60 through 2-79
	Building Service	2-80 through 2-99
3	Agriculture, Fishery, Forestry, and Kindred Occupations	
	Agriculture	3-00 through 3-49
	Fishery Occupations	3-80 through 3-89
	Forestry Occupations	3-90 through 3-99
4-5	Skilled Occupations	
6-7	Semiskilled Occupations	
8-9	Unskilled Occupations	

Most of the "0" coded vocations require college education and usually demand a high degree of academic and technical skill. Codes 4-, 6-, 8- and Codes 5-, 7-, 9- relate respectively to occupations in similar fields but in skilled (4-, 5-), semiskilled (6-, 7-), and unskilled (8-, 9-) categories. Codes 4- and 5- usually involve apprenticeship training and may involve a considerable degree of academic instruction. They require a high degree of manual skill and some technical and academic skill. Training in these skills can be developed in high school shops, technical schools, or on-the-job programs. The 6- and 7- codes are semiskilled trades and require little academic preparation. The 8- and 9- codes are unskilled and require little training, not over one week on the job.

Under the preceding headings, more than 40,000 different jobs are listed and defined in terms of the duties performed and the various phases of the job. Many classifications of occupations in the various sciences cut across this entire listing. Many are majors in one of the sciences, and many require combinations of training in several phases of science.

The list of occupations on page 44-49 is charted to convey a general idea as to the variety of jobs available, types of skills required, and the training necessary to meet with the greatest amount of success in each. Teacher and students alike can use these charts to advantage to gather occupational information about the jobs listed. This list is not complete, but constitutes a sampling of some of the occupations in which many workers are engaged.

PARTIAL LISTING OF SOME COMMON SCIENCE VOCATIONS

CODE
M—Much
S—Some
L—Little

*Refers to Dict. of Occupations Part I—Definitions

NAME OF VOCATION	TRAINING REQUIRED: Graduate	College	Tech. School	High School	Special (on job)	D. O. T. No.*	TYPE OF SKILL REQUIRED: Manual	Academic	Technical	MAJOR EMPHASIS: Biology	Chemistry	Physics	BRIEF DEFINITION
A. Agriculture													
1. Abattoir Work	—	—	—	X	X	4, 6, and 8	M	S	S	S	L	L	Slaughter and Meat Packing Workers
2. Agronomist	X	X	—	X	—	0-35.01	S	M	M	M	M	S	Soil and Crop Expert
3. Apiarist	—	X	—	X	X	3-07.70	M	S	M	M	S	S	Bee Keeper
4. Arboriculturist	—	X	—	X	—	0-35.05	M	M	M	M	M	S	Tree Expert
5. Author (scientific)	X	X	—	X	X	0-06.85	S	M	M	M	M	M	Writes Stories and Articles about Science
6. Dairy Farmer	—	X	—	X	X	3-04.10	M	S	S	M	M	S	Supervises Dairy Farm
7. Fisherman	—	—	—	X	X	3-87.	M	S	S	S	S	L	Gathers Salable Products in Fresh or Salt Water
8. Forester	X	X	—	X	—	0-35.07	M	M	M	M	M	M	Cares for and Manages Forests
9. Fruit Workers	—	—	—	X	X	3-15.27	M	S	L	S	L	L	Picks Fruit, Operates Grader and Packers
10. Fur Trapper	—	—	—	X	X	3-97.30	M	S	M	M	L	L	One Who Traps Fur Bearers for a Living
11. Game Protector	—	X	—	X	X	0-35.10	S	M	S	M	S	L	Protects Wildlife
12. Gardener	—	—	—	—	X	3-40.01	M	L	L	S	L	L	Cares for Flowers and Shrubs on Estates
13. Nurseryman	—	X	—	X	X	3-38.	M	L	S	M	M	S	Raises Trees and Shrubs Commercially
14. Livestock Farmer	—	X	—	X	X	3-07.10	M	L	S	M	M	L	Raises Animals for Food and Food Products
15. Pomologist	—	X	—	X	—	0-35.05	M	M	M	M	M	S	Fruit Specialist
16. Poultryman	—	X	—	X	X	3-08.10	S	S	M	M	M	S	Manages Hatching and Rearing Poultry

NOTE: This material has been reviewed by the U. S. Office of Education, Occupational Information and Guidance Section

CODE
M—Much
S—Some
L—Little

*Refers to Dict. of Occupations Part I—Definitions

NAME OF VOCATION	TRAINING REQUIRED: Graduate	College	Tech. School	High School	Special (on job)	D. O. T. No.*	TYPE OF SKILL REQUIRED / MAJOR EMPHASIS: Manual	Academic	Technical	Biology	Chemistry	Physics	BRIEF DEFINITION
17. Truck Farmer	—	X	—	X	X	3-09.10	S	S	M	M	M	L	Vegetable Farmer
18. Veterinarian	X	X	—	X	—	0-34.10	M	M	M	M	M	M	Animal Doctor
B. Biologist and Kindred Occupations													
1. Anthropologist	X	X	—	X	X	0-36.01	S	M	M	M	S	S	Specialist in History and Man's Biol. Devel.
2. Bacteriologist	X	X	—	X	—	0-35.33	S	M	M	M	M	S	Studies Kinds and Effects of Bacteria
3. Botanist	X	X	—	X	—	0-35.23	S	M	S	M	S	L	Plant Specialist
4. Cytologist	X	X	—	X	—	0-35.22	M	M	M	M	M	M	Studies Structure and Function of Living Cells
5. Ecologist	X	X	—	X	—	0-35.23	S	M	M	M	S	L	Studies Life and Its Relation to Its Environment
6. Embryologist	X	X	—	X	—	0-35.2	S	M	S	M	S	S	Specialist in Life before Birth
7. Entomologist	X	X	—	X	X	0-35.30	M	M	M	M	S	S	Insect Specialist
8. Herpetologist	X	X	—	X	X	0-35.28	M	M	M	M	S	S	Reptile Specialist
9. Histologist	X	X	—	X	X	0-35.41	M	M	M	M	M	S	Specialist in Living Tissues
10. Ichthyologist	X	X	—	X	X	0-35.28	M	M	M	M	S	S	Fish Specialist
11. Mycologist	X	X	—	X	X	0-35.25	M	M	M	M	M	S	Fungi Specialist
12. Oceanographer	X	X	—	X	—	0-35.65	S	M	M	M	S	S	Specialist in Geography of Oceans
13. Ornithologist	X	X	—	X	X	0-35.28	S	M	M	M	S	S	Bird Specialist
14. Paleontologist	X	X	—	X	X	0-36.02	M	M	M	M	M	S	Specialist in Prehistoric Life (Fossils)
15. Parasitologist (Plant)	X	X	—	X	X	0-35.21	M	M	M	M	S	S	Parasite Specialist

PARTIAL LISTING OF SOME COMMON SCIENCE VOCATIONS—Continued

CODE: M—Much, S—Some, L—Little

*Refers to Dict. of Occupations Part I—Definitions

NAME OF VOCATION	Training Required: Graduate	College	Tech. School	High School	Special (on job)	D. O. T. No.*	Type of Skill Required: Manual	Academic	Technical	Major Emphasis: Biology	Chemistry	Physics	BRIEF DEFINITION
16. Pathologist (Plant)	X	X	—	X	X	0-35.26	M	M	M	M	M	M	Disease Specialist
17. Taxidermist	—	—	X	X	X	0-66.95	M	S	S	M	M	S	Preserves and Stuffs Animals
18. Physiologist (Plant)	X	X	—	X	—	0-39.37	S	M	S	M	S	S	Specialist in Functions of Living Organs
19. Taxonomist	X	X	—	X	—	0-35.23	S	M	S	M	S	S	Specialist in Classification of Living Things
20. Zoologist	X	X	—	X	—	0-35.28	S	M	M	M	S	S	Animal Specialist
21. Psychologist	X	X	—	X	X	0-36.	S	M	M	M	S	S	Mind Specialist
22. Psychiatrist	X	X	—	X	X	0-26.19	S	M	M	M	M	S	Specialist in Treatment of Mental Diseases
23. Biochemist	X	X	—	X	—	0-07.02	S	M	M	M	M	S	Specialist in Chemistry of Living Things
24. Science Equip. Mfg.	X	X	X	X	—	5, 7, 9-09	M	S	M	S	S	M	Makes and Sells Scientific Apparatus
25. Collector (Plant Specimens)	—	X	—	X	X	3-49.	M	S	S	M	M	S	Collects and Sells Nature Specimens
26. Sanitary Engineer	—	X	—	X	—	0-16.	M	S	M	M	M	M	Devises Best Means of Waste Disposal
27. Irrigation Engineer	—	X	—	X	—	0-16.0	M	S	M	S	S	M	Devises Best Means of Crop Irrigation
28. Landscape Architect	—	X	X	X	X	0-03.20	M	M	M	M	M	M	Engineers Contouring and Planting Landscapes
29. Laboratory Technician	—	—	X	X	X	0-50.	M	S	M	S	M	S	Aids Research and Tests in Science Laboratory
30. Medical Specialists													
a. Physician	X	X	—	X	X	0-26.10	M	M	M	M	M	S	Doctor Who Administers Medicines
b. Surgeon	X	X	—	X	X	0-26.	M	M	M	M	M	M	Doctor Who Specializes in Operating
c. Osteopath	X	X	X	X	—	0-39.96	M	M	S	M	S	M	Heals Illnesses by Manipulation of Body Parts

COMMON SCIENCE VOCATIONS—Continued

CODE
M—Much
S—Some
L—Little

*Refers to Dict. of Occupations Part I—Definitions

NAME OF VOCATION	TRAINING REQUIRED: Graduate	College	Tech. School	High School	Special (on job)	D. O. T. No.*	TYPE OF SKILL REQUIRED: Manual	Academic	Technical	MAJOR EMPHASIS: Biology	Chemistry	Physics	BRIEF DEFINITION
d. Dermatologist	X	X	—	X	X	0-26.	M	M	M	M	M	S	Skin Disease Specialist
e. Masseur	—	—	—	X	X	0-52.41	M	S	L	S	L	S	Massage Expert
f. Chiropodist	—	X	—	X	X	0-52.01	M	S	S	S	L	M	Foot Doctor
g. Oculist	X	X	—	X	X	0-26.	M	M	M	M	S	M	Eye Specialist
h. Orthodontist	—	X	—	X	X	0-13.10	M	S	M	M	M	M	Dentist Who Specializes in Corrective Work
i. Neurologist	X	X	—	X	X	0-26.	S	M	M	M	M	M	Nerve Specialist
j. Cardiologist	X	X	—	X	X	0-26.	S	M	M	M	S	S	Heart Specialist
k. Pediatrician	X	X	—	X	X	0-26.	S	M	M	M	M	S	Specialist in Treating Children's Diseases
32. Museum Curator	—	X	—	X	X	0-39.03	M	M	M	M	S	M	Manages the Preparation of Museum Displays
33. Nature Artist	—	—	X	X	X	0-04.	S	S	M	S	M	M	Paints and Draws Pictures of Wildlife
34. Nature Photographer	—	—	X	X	—	0-56.	M	S	M	M	S	S	Takes Pictures of Wildlife
35. Pharmacist	—	X	—	X	X	0-25.	M	S	M	S	M	S	Mixes Chemicals for Medicines
36. Teacher	X	X	—	X	—	0-11 and 0-31	S	M	S	M	M	M	Instructs Students in Science Subjects
37. Nature Counselor	—	X	—	X	X	0-27.15	M	M	S	M	S	L	Conducts Field Trips and Classes in Nature Study in Summer Camps
38. Agricultural Chemist	—	X	X	X	—	0-07.	M	M	M	M	M	S	One Who Advises on Crop, Fertilizers, Animal Feeds, Tonics, etc.
a. Spray Expert	—	—	X	X	X	3-01	M	S	M	S	M	S	Specialist in Insecticides and Fungicides
b. Fertilizer Mixer	—	—	X	X	X	4-52.11	M	S	M	L	M	S	Determines Proper Chemicals to Be Used in Making Fertilizer

PARTIAL LISTING OF SOME COMMON SCIENCE VOCATIONS—Continued

CODE
M—Much
S—Some
L—Little

*Refers to Dict. of Occupations Part I—Definitions

NAME OF VOCATION	TRAINING REQUIRED: Graduate	College	Tech. School	High School	Special (on job)	D. O. T. No.*	TYPE OF SKILL REQUIRED: Manual	Academic	Technical	MAJOR EMPHASIS: Biology	Chemistry	Physics	BRIEF DEFINITION
c. Animal Medicine and Tonic	—	X	X	X	X	4, 6, 8-53	M	S	M	M	M	S	One Who Mixes Medicine for Animals
d. Hormones Expert	—	X	—	X	—	0-07.	S	M	M	M	M	L	One Who Studies Composition and Effect of Hormones on Life
39. Chemical Engineer	X	X	—	X	—	0-15.01	M	M	M	S	M	M	Conducts Engineering Projects in Field of Chem.
40. Metallurgist	—	X	—	X	—	0-14.	M	M	M	L	M	M	Determines Metallic Content of Ores and Uses of Same
41. Petroleum Chemist	—	X	—	X	—	0-07.	S	M	M	L	M	M	Determines Best Methods of Refining and Using Petroleum
42. Research Chemist	X	X	X	X	X	0-07.	M	M	M	S	M	M	Conducts Chemical Research
43. Ceramics Expert	—	X	X	X	—	0-15.11	M	M	M	L	M	M	Develops Uses of Clay and Clay Products
44. Building Materials Expert	—	—	X	X	X	0-99.21	M	S	M	L	M	M	Develops More and Better Uses of Cement, Sand, etc.
45. Glass Maker	—	—	X	X	X	4, 6, 8-65.	M	L	S	L	S	M	Supervises Making of Glass and Glass Products
46. Auto Mechanic	—	—	X	X	X	5-81.010	M	S	M	L	S	M	Repairs Automobile Parts
47. Fuels Expert (Combustion Engineer)	—	X	X	X	X	0-19.01	S	S	M	S	M	M	Determines Best Use of All Types of Fuels
48. Lubricant Expert	—	X	X	X	X	0-39	M	S	M	L	M	M	Develops Proper Uses of Oils and Greases
49. Welder	—	—	X	X	X	4-85	M	S	M	L	S	M	Joins Metals with Elec. Arc. or Oxy-Acetylene Torch
50. Sanitary Inspector	—	X	—	X	X	0-95.16	M	S	L	S	M	L	Inspects Restaurants, Toilets, Pools to Prevent Disease
51. Cabinet Maker	—	—	X	X	—	4-32.100	M	S	M	L	S	M	Builds Articles of Wood

COMMON SCIENCE VOCATIONS—Concluded

CODE
M—Much
S—Some
L—Little

*Refers to Dict. of Occupations Part I—Definitions

NAME OF VOCATION	TRAINING REQUIRED: Graduate	College	Tech. School	High School	Special (on job)	D. O. T. No.*	TYPE OF SKILL REQUIRED: Manual	Academic	Technical	MAJOR EMPHASIS: Biology	Chemistry	Physics	BRIEF DEFINITION
52. Sheet Metal Worker	—	—	X	X	—	4-80.	M	S	M	L	S	M	Builds Articles of Metal
53. Mason	—	—	X	X	—	5-24.	M	S	M	L	S	M	Uses Plaster, Mortar, Cement, Clay, to Build and Construct
54. Painter	—	—	X	X	—	5-27.01	M	S	M	L	S	M	Paints Wood, Metal, and Masonry Surfaces for Protection and Beauty
55. Explosive Expert	—	—	X	X	X	6-52.4	S	S	M	L	M	M	Directs Making and Proper Uses of Explosives
56. Textile Chemist	—	X	X	X	X	0-07.	M	M	M	S	M	M	Directs Making, Dyeing and Finishing of Fabrics
57. Dye Expert	—	X	X	X	X	5-18.01	S	S	M	S	M	S	Develops Making and Proper Uses of Dyes
58. Civil Engineer	—	X	—	X	—	0-16.01	M	M	M	S	M	M	Designs and Directs Construction of Public Facilities
59. Acoustical Engineer	—	X	—	X	—	0-17	M	M	M	S	S	M	Sound Specialist
60. Mechanical Engineer	—	X	—	X	—	0-19.01	M	M	M	S	M	M	Plans and Aids in Solving Mechanical Problems
61. Mining Engineer	—	X	—	X	—	0-20.0	M	M	M	L	M	M	Directs Removal of Mineral Deposits from Earth
62. X-ray Technician	—	X	—	X	X	0-50.04	M	S	M	S	S	M	Assists in Taking and Developing X-ray Pictures
63. Atomic Research Physicist	X	X	—	X	—	0-35.7	M	M	M	M	M	M	Assists in Developing Use of Atomic Energy
64. Electronics Physicist	X	X	X	X	X	0-35.	M	M	M	M	S	M	Studies the Radar, Sonar, etc., Uses
65. Television Expert	—	X	X	X	X	0-17.	M	M	M	L	M	M	Develops Types and Uses of Television Sets
66. Aviation Expert	—	X	X	X	X	0-19.03.	M	S	M	L	S	M	Aids in Designing and Building Aircraft
67. Biophysicist	X	X	—	X	—	0-39.4	M	M	M	M	M	M	Studies Relation of Physics to Living Cells
68. Auto Body Expert	—	—	X	X	X	5-81.51	M	S	M	L	S	S	Repairs Car Bodies and Fenders

Sources of Vocational Information

For students and teachers who desire to investigate further the details of salary possibilities, future trends, advantages and disadvantages, personality factors in success, and steps to better jobs, the following sources of information are valuable:

1. Chief, Occupational Information and Guidance
   Department of Public Instruction
   Harrisburg, Pennsylvania

   There is available in this Division much printed material and audio-visual aids for the cost of postage.

2. Local State Employment Office—A Division of the State Department of Labor and Industry. Located in all population centers.

   An excellent source of current trends in the labor market, and of counseling and testing service available free of charge to schools and out-of-school youths.

3. California Test Bureau
   5916 Hollywood Boulevard
   Hollywood, California

   A fine set of tests, together with handbooks for teachers in guidance. Tests are helpful in aiding students to determine fields of interest as well as aptitudes.

4. U. S. Department of Labor and U. S. Department of Agriculture, Washington, D. C.

   Send for list of publications in career and occupational information. Much material is available through this source at low cost.

5. Science Research Associates
   228 South Wabash Avenue
   Chicago, Illinois

   Pamphlets and booklets on specific careers, as well as tests and measuring devices for determining interests and aptitudes.

6. Institute for Research
   Chicago, Illinois

   An excellent set of Career Monographs on most careers in the usual scientific fields. All are written by experts in their respective fields. Somewhat expensive.

7. McGraw-Hill Book Company, Inc.
   330 West 42nd Street
   New York, New York

   A wide range of guidance books for use of teachers and guidance specialists in vocational counseling. Send for list.

8. Vocational Guidance Films, Inc.
   7514 North Ashland Avenue
   Chicago 26, Illinois

   Excellent listing of films in many careers in fields of science.

9. Guidance Chronicle Press
   Moravia, New York

   Periodic literature on labor market and careers information. Low cost and very authentic.

Selection of a Vocation

The selection of a vocation is not necessarily a rapid process, but may continue over a period from preadolescence until after high school with no ill effects. Little alarm should be felt by the high school seniors or college freshmen who have not yet determined their careers. As more and more occupational information is presented to them they will sooner or later find something that is

most interesting to them. It is the responsibility of teachers to present this information and make possible other ways of learning about jobs by varied types of experience.

A general analysis of a student's mental and manual abilities, personality factors, and interests should be made available to him if at all possible, so that he may judge more clearly his relationship to requirements that have to be met in vocations which he is investigating.

This information does not preclude the importance of other subjects in career selection, or in the development of a well-rounded personality. Many vocational opportunities are open to specialists in language arts, mathematics, social sciences, and the other subject fields.

The development of an experience unit in teaching occupational information in science is highly recommended. Such a plan may take the following form:

WHAT CAREER SHALL I CHOOSE?

1. *Objectives*
   a. To learn the names of vocations in science fields
   b. To understand the general requirements to be met
   c. To find out the fields of science to be emphasized
   d. To discover the skills and their development
   e. To analyze own interests and abilities for scientific work
2. *Activities*
   a. Talks by experts—careers conferences
   b. Library research by academic students
   c. Trips and excursions to industry, business, farms, etc.
   d. Audio-visual aids, "Scientific Occupations"
   e. Students develop A JOB ANALYSIS of careers in which they are interested, and which will include:
      (1) History of the job
      (2) Divisions of the field of work
      (3) Beginners' jobs—steps to advanced jobs
      (4) Requirements to be met
      (5) Working conditions
      (6) Advantages and disadvantages
      (7) Summary
3. *Culminating Activities*
4. *Evaluation*

SECTION 6

COOPERATING WITH TEACHERS OF OTHER SUBJECTS

Promoting growth toward maturity and developing the learner as a whole person are vital goals in science education. Teaching of science only through abstract thinking or strict adherence to separate subject matter fields is a doubtful approach to the attainment of these purposes. Under such teaching, pupils are not practiced in tying together the segregated facts to which they are exposed. Many fail to see the relationships prevailing between scientific

principles and social issues. They fail to understand the economic-industri life and to develop an appreciation of the close relationship between scientif knowledge, human achievement, personal welfare, industrial progress, an economic trends.

How many pupils are aware of the impact which mass productio resulting from the interchangeable parts of machines, has had c economic trends and social problems? Or what possible effects the d velopment of atomic enegry will have on the economic trends of suc industrial enterprises as coal and petroleum? Or what effect a knowled of the racial heritage has on the formulation of sound judgments an an effective understanding of present-day problems?

The recognition of these problems and the development of relatio ships between other subject fields and science education will contribu to curriculum improvement and the growth of the pupil. Wheth science is taught for general education or for specialization in fields biology, chemistry, and physics, it should not be considered apart fro other aspects of school experience. The study of science in its vario phases is closely related to the other subjects of the curriculum and offe many opportunities for cooperation that will be helpful in the scien classes and in phases of other subjects.[2]

A school faculty should work together as a team. This ability evidence of faculty leadership. Unless faculties can cooperate in th treatment of some life problems, the individual student cannot be e pected to integrate all the material from many segregated subjects actually solving problems for himself.

HOW CAN WE CARRY OUT A COOPERATIVE PLAN?

Curriculum improvement can be carried out within the framewo of departmentalization and, if need be, on the basis of individual pla ning with the cooperation of other subject area teachers. Duplicati and confusion will then be at a minimum. Other types of approa that can be made by schools are classified in the manual on *Improveme in Secondary Education Through Group Studies,* Fifth Yearbook of t Pennsylvania Branch, National Association of Secondary-School Prin pals, as follows:[1]

1. Subject-matter curriculum reorientation through subject uni pointed toward adjustment education objectives
2. Broad fields approach by combining fields within a school subje for example, biology and physical science
3. Problem approach
   a. In a single subject
   b. Involving several subjects
4. Core curriculums

PLANNING A LIFE SCIENCE CURRICULUM

Irrespective of the basis of action, the end result for a school faculty may well be some integrated units, or groups of units, that will contribute to desirable behaviors in home and community life, political citizenship, ethical and moral values, relationship as a worker, scientific understandings, communication skills, consumer judgment, and recreational activities. Many of these problems are critical in American life. Secondary education is being taken to task for failure to emphasize their solution. This involves faculty cooperation for concurrent study of these problems in various subject areas.

Poems, biographies, or essays are not to be used exclusively in English classes. Teaching the appreciation of reading, writing, and the racial heritage are as much a duty of the science teachers as the scientific method of thought, developed through the study of science, is applicable to other areas of study. A program of selective readings similar to the pattern in English should be a recommendation in all science classes. The science teacher who teaches science and nothing else fails in the full scope of his teaching.

Only through a careful exploration of science problems in social living can teachers succeed in providing a related program. This will require a cooperative study of the community and the country; current

problems; young people, their needs and interests; and methods adaptable to the varying levels of maturity.

Suggested List of Opportunities to Carry Out a Survey Within a Faculty

1. With work in *mathematics* classes in meeting many of the problems that arise in the physical sciences and in some phases of biological sciences

2. With *social studies* in such subjects as:
   a. Community health, safety, living standards, recreation, and beautification
   b. The development of methods of transportation, communication, certain utilities, various industries
   c. Use and conservation of natural resources
   d. Historical and scientific phases of various inventions
   e. Relation between scientific and industrial progress and economic trends
   f. Lives of noteworthy scientists
   g. The international character of science

3. With *English* classes through:
   a. The study of scientific terms (origin, meaning, pronunciation, and spelling)
   b. Reading based on materials of scientific interest and on the lives of noted scientists
   c. The use of scientific topics in written composition and written reports
   d. The use of scientific topics in oral composition and oral reports

4. With *foreign language* classes in such matters as:
   a. The study of scientific terms of foreign derivation
   b. The study of scientific discoveries and inventions that have had their origin in foreign countries
   e. Reading based on the lives of noted foreign scientists
   d. Development of the ability to read scientific material in foreign languages, such as will be needed for advanced study in certain sciences

5. With *merchandising* classes in:
   a. The study of the sources of various articles of merchandise
   b. The manufacture of synthetic materials used in certain merchandise
   c. Testing for authenticity of goods

6. With *art* classes in the application of principles of color and light

7. With *music* classes in:
   a. The application of the principles of sound
   b. The study of the construction of various musical instruments
   c. The use of the vocal organs in vocal music

8. With classes in *physical and health education* in the study of:
   a. Personal hygiene
   b. Community hygiene
   c. Physiological conditions and processes
   d. Individual physical needs
   e. Principles of first aid

9. With *industrial arts* classes in:
   a. The study of woods, metals, etc., used in the construction of furniture and other household articles
   b. The study of the construction and operation of machines
   c. The sources of electric power and uses of electricity
   d. The principles and processes involved in printing

10. With *home economics* classes in:
    a. All phases of the study of foods (production, preparation, nutritive values, care, and use)
    b. The study of textiles, clothing, etc.
    c. The study of machines used in the home

A CHALLENGE FOR COOPERATIVE ACTION BY A HIGH SCHOOL FACULTY

The following resource unit has been developed by a State Committee. This committee was organized for this purpose. (See Appendix.) The unit on Family Life Education represents opportunities for cooperative faculty action in constructive work on problems that may, if neglected, undermine our way of life.

Material on this unit includes similar sections which are devoted to other subject areas. This is included in the courses of study for these subjects. Cooperative faculty action will result in the needed assembling of materials for effective planning.

FAMILY LIFE EDUCATION IN THE TOTAL SCHOOL PROGRAM

Philosophy

What Do We Mean by Family Life Education?

Family Life Education is the total program within a school directed toward improving family living. It is the sum total of all concepts, attitudes, and skills gained in home and family living through a coordinated, well-planned program. Although courses in Family Relationships and Sex Education are sometimes called Family Life Education, the term Family Life Education is generally conceded to be broader in scope than any one course.

Who Is Responsible for Family Life Education?

Everyone concerned with the growth and development of youth today will have a part in this program. To coordinate such a program in a school will mean the setting up of a working committee representing every subject matter area in addition to school dietitian, nurse, guidance counselor, parents, and young people. The homemaking teacher because of her unique background will be a valuable member if not the leader of this committee.

All courses offered in Homemaking,* i. e., the family's food, clothing for the family, child care and development, home management, home nursing, personal and social relations, will naturally be a fundamental and major part of this program in Family Life Education. To function constructively in the everyday living of boys and girls these courses must be family-centered. Music and art too have much to contribute to happy family living. Health and physical education will have a vital place in such a program. If the subject matter areas of English, science, mathematics, geography, modern foreign languages, social studies are to meet the needs and concerns of youth today, they too must relate part of their work to the family and the community of which the family is a part. Thus, every member of the school staff must recognize the part he or she has in developing improved attitudes toward the home. *Every* teacher has a contribution to make to family living by helping boys and girls understand the values of home life and how to become responsible family members.

Education for Family Life, as far as the school is concerned, should begin with the preschool child and continue through the twelfth grade, for both boys and girls. The new *Elementary Course of Study,* Bulletin 233-B Department of Public Instruction, 1950,

* Bulletin No. 325, *A Suggested Program in Homemaking for Secondary Schools,* Department of Public Instruction, Harrisburg, 1948.

treats the subject under Chapter II, "Providing for Some Aspects of Education that Permeate the Whole Day," specifically, "Building Good Family Relationships through School Activities," p. 61. In order to meet more adequately the needs of the high school senior, a specific unit should be offered in family relationships, giving emphasis to preparation for marriage. Many high schools are providing such units under various titles, such as: Personal Living; Family Relationships; Senior Problems; Problems of Modern Living. This unit can be taught best by a person who is mature, well adjusted, skilled in human relations, willing to listen to young people.

EDUCATION FOR FAMILY LIFE: A RESOURCE UNIT

General Objective: To Strengthen and Improve Family Living

Specific Goals for Total School

To help boys and girls to:

1. Understand themselves and how their behavior affects others
2. Recognize the needs and desires of others in the family group
3. Appreciate the value of good mental and physical health for personal happiness and wholesome family living
4. Understand the place and importance of children in the home
5. Gain an appreciation of human and spiritual values in family living
6. Respect the contributions people of other cultures and races make to home and community living
7. Understand the need for cooperatively planned management in every home
8. Appreciate the need for beauty in the home
9. Recognize the responsibilities families have toward the community
10. Appreciate the responsibilities involved in parenthood and homemaking
11. Recognize factors which influence our standards for the selection of a life partner
12. Understand the home as a social institution and as a basic unit of democracy
13. Understand the value of the scientific approach to the solution of family problems

Some Suggestions for Integrating Family Living With the Subject Matter Areas

NOTE: In this report no attempt has been made to indicate the scope of subject matter in Family Life Education. Typical items have been selected to serve as illustrations.

INTEGRATION WITH SCIENCE

Specific Goals	*Content*	*Experiences*	*Teaching Aids*
To understand the value of the scientific approach to the solution of family problems.	Use of the scientific rather than an emotional approach as a means of solving family problems.	Dramatize the solution of a family problem both by critical thinking and by an emotional approach.	
	Sifting out of advertising the scientific facts that have a bearing on the worth of a particular product from those having none.	Compare the statements made in advertising a product on the radio, television, in magazines or newspapers with facts as they actually exist.	*Learning to Use Advertising*, Consumer Education Series, National Association of Secondary-School Principals.
	The principles of science underlying the many household gadgets on the market: Criteria for selection. Their care and use.	Examine articles that pupils bring from home. Consider satisfactions derived from use, cost, construction. Field trip to store.	
	Being an intelligent consumer involves obtaining information about the things you buy and using this information.	Examine materials and clothing for labels. Ask before buying cotton clothes if they are Sanforized. Find out government regulations on grading and labeling.	*Using Standards and Labels*, Consumer Education Series, National Association of Secondary-School Principals.
	Scientific advances and their effect on family life have raised our standard of living but have created some of the social problems affecting home life: Labor-saving devices. Home building. Radio, television, etc.	Make a survey of the number and kinds of labor-saving devices in homes today. Use the results of this survey as a basis for discussions of their real values vs. "keeping up with the Joneses" values. Discuss the changes that scientific advances have made in our pattern of family living within the past fifty years.	*Chemistry and the Home. Better Things for Better Living through Chemistry*, Extension Division, E. I. Du Pont De Nemours & Co., Inc., Wilmington 98, Delaware.

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Teacher Reference

Thut & Gerberich: *Foundations of Methods for Secondary Schools.* McGraw-Hill Book Company, Inc., 1949.

Spafford: *A Functioning Program in Home Economics.* John Wiley & Sons, Inc., 1940.

American Journal of Sociology (May, 1948: The American Family), Univ. of Chicago Press, Chicago, Ill.

California Journal of Secondary Education (January, 1950), 170 S. VanNess Ave., San Francisco 3, Calif.

National Ass'n Secondary-School Principals, 1201 Sixteenth St., N. W., Washington 16, D. C. *How Well Does Your High School Rate on the Imperative Needs of Youth?*—$.20.

Stratemeyer, Forkner and McKim: *Developing a Curriculum for Modern Living,* Columbia Univ., New York.

Teacher and Pupil Reference for Family Relationships

Duvall: *Family Living.* The Macmillan Company, 1950.

Groves-Skinner-Swenson: *The Family and Its Relationships.* J. B. Lippincott Company, 1948.

Landis: *Your Marriage and Family Living.* McGraw-Hill Book Company, Inc., 1946.

Sources from Which Free and Inexpensive Material Can Be Secured

American Institute of Family Relations—5287 Sunset Boulevard, Los Angeles, Calif.

American Social Hygiene Association—1790 Broadway, New York 19, N. Y.

Association for Family Living—28 E. Jackson St., Chicago 4, Ill.

Child Study Association—221 W. 57th St., New York, N. Y.

Federal Security Agency—Public Health Service, Washington 25, D. C.

National Council on Family Relations—1126 E. 59th St., Chicago 37, Ill.

Parents' Magazine—52 Vanderbilt Avenue, New York, N. Y.

Public Affairs Committee, Inc.—22 E. 38th Street, New York 16, N. Y.—Booklets—$.20 per copy.

Science Research Associates—228 S. Wabash Ave., Chicago 4, Ill.—Life Adjustment Booklets—$.60 per copy.

Syracuse University Press—Syracuse, N. Y.—*A Bibliography of Family Life Materials.*

	Films (16 mm.—Sound)
Examples of:	Consult film lists from:
Family Life in Other Lands	American Junior Red Cross Encyclopaedia Britannica Pennsylvania State College Film Library Young America Films
Family Life in the Days of Our Forefathers	
Colonial Children	The Pennsylvania State College Film Library—Rental $1.50
Modern Family Living	New York Commission on Human Relations
Dead End Children	New York University, 26 Washington Place—Rental $2.00
Consumer Protection	Coronet Films—Rental $1.50
Family Affair	New York University, 26 Washington Place, N. Y.—Rental $4.00
Family Life	Coronet Films—Rental $1.50
Make Way for Youth	Association Films, 347 Madison Ave., N. Y.—Rental $1.50
You and Your Family	Association Films, 347 Madison Ave., N. Y.—Rental $1.50
Family Teamwork	Frith Films, 840 Seward St., Hollywood 38, Calif.
Families First	New York State Department of Commerce Film Library, 40 Howard Street, Albany, N. Y.—Rental $3.00
	Filmstrips
Happily Ever After	Film Publishers, Inc., 25 Broad Street, N. Y. C.—Cost $3.00
As Others See You Home Ground School Spirit Stepping Out Table Talk	McGraw-Hill Book Company, Inc., 330 W. 42d St., N. Y. C.—Cost $4.50 each

SUMMARY

1. The all-around development of the learner is a goal in science education. If this is to be achieved, the teacher must: (1) tie together segregated facts into understandings, attitudes, and behaviors, and (2) start directly with life problems and develop factual knowledge in a functional matrix.

2. An all-around educational experience for youth, in the treatment of his personal and social problems, is not the sole job of any one subject. Many problems involve the cooperation of all teachers simultaneously.

3. Faculty team-work is evidence of good leadership. Faculty conferences are needed for this development.

4. Faculty cooperation is necessary for integration by the student of what he learns from separate subject areas.

5. Each subject area has much concern with science education. Many possibilities exist likewise for science education to make contributions to other areas.

6. The critical problem of home and family living is an example of a social problem which merits vigorous, cooperative faculty action.

SUGGESTED READING

1. *Improvement of Secondary Education Through Group Studies,* Fifth Yearbook of the Pennsylvania Branch, National Association of Secondary-School Principals, Upper Darby, Pa., 1949.

2. Laton, Anita Duncan, and Powers, S. R., *New Directions in Science Teaching.* New York, McGraw-Hill Book Company, Inc., 1949.

3. Overstreet, H. A., *The Mature Mind.* New York, W. W. Norton & Company, Inc., 1949.

4. *Science Teaching in American Schools,* Forty-sixth Yearbook of the National Society for the Study of Education. Chicago, University of Chicago Press, 1947.

SUMMARY OF CHAPTER II

1. A science program should *meet the needs of both the academic and nonacademic* students. These needs may be met by two separate courses or by differential subgrouping in a single course. The gains of the functional science program will increase the mastery of otherwise theoretical memorized content.

2. All students should have *individual laboratory experiences* in the entire science program. Probably the greatest contribution lies in the methods which scientists use in solving problems. The laboratory is the key experience in problem-solving. The students should have experience in discovering for themselves, using laboratory methods and skills.

3. Students should see *demonstrations* of scientific principles performed by the teacher as well as have the opportunity to do experiments themselves. Seeing a skilled person perform a demonstration is an incentive to become skilled.

4. Students should have the opportunity to take *field trips.* The actual materials in actual situations constitute the best visual aid material obtainable. Most communities are rich in materials suitable for field trips. Reading should not be

substituted for direct experience where the latter is available. Museums, planetaria, farms, swamps, industrial plants, water works, sewage disposal plants, woodlands, etc., are possible resources for field trips.

5. Students should *work on problems in groups.* A small group of students working together to solve a problem of mutual concern constitutes an excellent exercise of good citizenship. The best guarantee that students will work together in the future is practice in working together today. Group leadership should be rotated so that all get experience in leading.

6. Each student should be stimulated to do an *individual project* of some length in each course, as well as to work in groups. Individual differences and individual living require students to work by themselves as well as in groups.

7. Common and easily obtained *teaching materials* constitute a major portion of the equipment for the secondary school science program. The schools should provide for necessary laboratory equipment to illustrate principles, but students need also to learn the principles involved in the common materials in their surroundings. Electric pumps, living animals, aquariums, dry cells, auto jacks, old clocks, plants are examples.

8. A probable *order of teaching procedures* is as follows: (1) pupil-group doing, (2) individual pupil doing, (3) demonstrations, and (4) teacher telling. However, for some kinds of learning, any one of the above may have maximum value. The pupil learns what *he* does.

9. *The science program should be organized in units* rather than in day-to-day assignments. The unit provides for problem approaches and diversified activities. The day-to-day assignment implies that the problem has no unity for the student and that he must be told what to do each day. Units relate bits of information to whole understandings.

10. There are times when students *should be given an opportunity to pass judgment on their own work* and that of the group in which they are working. How well did they work together? Did the leader do a good job? What was the work worth?

11. *The evaluation of skills and attitudes is a challenge.* The methods of evaluating skills and attitudes have not been developed nearly so well as the methods of evaluating information. However, attempts should be made. Teachers agree that careful subjective evaluations can be valid.

12. *Students should be given the opportunity to select* some units of work or activities in a unit in the science program. Guidance should be provided, although care should be taken not to dominate the student's choice. Since science is a tool for problem-solving, its application to the felt needs of the students should result in the most fruitful use of science.

13. *The teacher should select units for study for which there is a definite need.* Since student-selected units may not suffice to develop particular objectives, the teacher will need to introduce units to do so.

14. *Students should have many opportunities to challenge statements* of authorities, whether the authority is the teacher, a reference, or fellow student. Students should have many opportunities to conduct experiments in attempts to prove a point in contradiction to an authority.

15. *The teacher should exemplify the scientific method* in the classroom by:
    1. Avoiding dogmatic statements.
    2. Showing how to learn instead of telling.
    3. Allowing students to question statements of the teacher.
    4. Avoiding argumentation.
    5. Stating problems clearly.

16. *The science program should show many applications* of the effect of the scientific method on daily living. New machinery, new drugs, sources of energy, population changes provide many possible topics for discussion.

17. Science classes should provide many *opportunities for hobbies* which are useful for leisure time. Collecting, bird walks, photography, hunting and fishing, telescope making, identifying rocks or minerals are examples of hobbies to encourage.

18. Actual experience in *conservation* projects in the community, either as a class or as individuals, is superior to class discussion of conservation procedures. Such projects constitute desirable laboratory activities and contribute greatly to citizenship education.

19. Secondary students should have *definite classroom responsibilities*, such as preparing bulletin boards, cleaning up after laboratory periods, improvising equipment, assisting in the laboratory periods, and caring for stockrooms, and operating projectors.

20. Students should have an opportunity to hear local *hobbyists* and experts discuss their specialties in science classes. Teachers cannot be expected to know all specialized science fields, but they should draw on qualified resource people in the community for assistance.

21. The use of *many textbooks and other references* is superior to the use of a single text. Assignments by problems is superior to the assignment by pages in the text. Supplementary references should be used in addition to textbooks.

22. Abundant use should be made of *lantern slides, moving pictures, and filmstrips* to illustrate points made by the class or the instructor. Care should be taken not to replace actual materials with pictures, when actual materials are available.

23. Students should have the opportunity to meet with the instructor in *informal out-of-class activities* to exchange ideas. Science fairs, science clubs, and field trips provide excellent opportunities for informal relations. Such situations may well take place during the regular class work.

CHAPTER III

SCOPE AND SEQUENCE OF SCIENCE TEACHING

The only purpose of a course of study is to increase pupil learning. Present-day courses are planned to promote and assist the types of planning and teaching which grass-roots contributions have shown to be effective. A course of study is in no sense a syllabus. Nothing can be substituted for excellent teacher initiative in adapting flexible suggestions to the requirements of the learning situations which the teacher is called upon to plan and to guide.

USING A COURSE OF STUDY

It may be a difficult problem at first for some teachers to use a course of study in creating an effective curriculum for the pupil. Here experience produces rapid success. Effectiveness for the pupil depends upon the extent to which he identifies himself with the goals and activities which are planned. If he helps democratically in the planning, his identification is more complete. Meaningfulness—goals or plans which meet pupil-needs or provide goals which he recognizes—is necessary for pupil participation and genuine learning experiences.[3] Motivation should be intrinsic in the planning. The mind takes what it reaches for.

A most significant contribution to education has been made during the present generation. A scientifically derived psychology of learning has resulted in a distinct shift from ways of presenting content to be assimilated to ways of guiding the learning activities of students. The business of teaching is to help students, through practice, to acquire the behaviors—thinking, feeling and acting—that will assure the best possible adjustments to their environments.

The habitual day-by-day recitation is a relic of outmoded method. There is satisfaction in professional growth as a teacher gains new insights and skills in guiding the learning activities of youth. Then he can transform his classroom from a lesson-hearing room to an active learning laboratory. The quality and variety of the learning activities which he plans determine the quality of the learning which takes place. Here a course of study provides assistance.

SCOPE

Since learning is the changes of behavior which are needed for adjustment to the student's environment and to his immediate future needs,

NOTE: Superior figures in the content refer to numbered items in suggested reading list on p. 66.

science education performs a great function. To be valid, it must be as broad as life itself. It must include both general adjustment problems and those of a specific and unique type, such as pretechnical preparation. In the full range of its scope, it must:

1. Survey the personal-social scientific needs of individual youth and those of society.
2. Formulate behavior goals, on the basis of functional utility (power in satisfying a want), making selection on: (a) frequency of application, (b) cruciality, (c) many-sidedness (transfer) value, and (d) personal appeal to students at their maturity levels.[5]
3. Plan activity programs to evoke the pupil learning experiences which provide practice in the behaviors of thinking, feeling, and acting which are needed for both life adjustment and college preparation.

In the wholeness of these concepts, factual data and information hav meaning. In the functional context in which they come to life, they ar best learned and longer retained.

SEQUENCE

"Strike when the iron is hot" is an old motto that has but recently bee applied to education. For too long, sequence was determined only by th logic of the subject itself. This served very well when the filling-station ide of education prevailed. Now the dynamics of individual and group actio emphasize the fact that logical organization by itself is not always effectiv

A logical plan may have symmetry, simplicity, and clarity to th teacher, but learning experiences are psychological. The way the studen is motivated by emphasizing his needs and future plans may determin how he thinks and goes about things in an experimental way. Th behavior is as significant as the knowledge and skill which he masters. contributes greatly to mastery itself.

Readiness for the acquisition by youth of certain types of knowledg and behavior exists at different levels of maturity.[3] Unless the need adjustments are made at that time, they are probably never made at al Areas of suspended adolescence exist in many who have mature bodi Scientific understandings and attitudes, if taught effectively, can becon part of the character structure of youth in creating desirable adjustme behaviors, lifelong interests, and preprofessional backgrounds.

In addition, the principles of going from the known to the unknow from the simple to the complex, from the here to the far, provide rection. This type of planning adds to the ability of the learner integrate and to use what he learns. Too often, however, crucial pro lems close at hand may be neglected by a type of planning that is n sensitive to their existence.

ORGANIZATION

There are individuals who envision a course of study with scope and sequence developed opportunistically by teachers and pupils. However, preplanning is undoubtedly necessary if a course of study is to be comprehensive. In addition, there are those who believe that scope and sequence should be planned entirely on the basis of life problems if the science program is to be maximally functional. Each of these convictions has possible virtues. It is best to avoid an "either-or" attitude.

On the one hand, this course of study suggests that opportunistic timely teaching be used. Unusual natural phenomena, immediate pupil problems, coming events, and even daily occurrences may provide centers of interest that promote the best kinds of learning. In addition, the great problems of life adjustment must have place and status in any effective program of teaching. The direct consideration of these life-problems in guided-group problem-solving activity is a valid scientific experience for pupils. More units and logs of successful teaching experiences of these types are greatly needed for distribution to teachers who may not have gained the ability to plan and produce learning experiences of this type. Complete organization on this basis, however, will require much more successful research and reports.

On the other hand, subject-matter planning, organized on a sequence of scientific principles and understandings rather than as isolated factual data, is the accepted procedure.[6] Selection and sequence are based on the needs of the individual and society rather than upon the sequential study of bits of abstract information. In this pattern, factual data and information are placed in a functional systematic context which contributes to their comprehensive mastery, to their proper relationships to each other and to life, and to their effect on the learner.

Lateral enrichment is provided by listing and emphasizing behavior objectives and many learning activities to provide for the learner's continuous reorganization of experience.[1] These objective and related learning activities will not be neglected in the valid use or adaptation of the material which is presented in this course of study.

Frequently teachers who can do so are challenged to develop and to use in the sequence direct life-problem units which are focused on pupil needs. "What Shall We Eat?"—"How Can We Keep Well?"—"How Shall We Buy Good Food and Clothes?"—"How Can We Pick a Good House?" The solution to these and other critical human problems will be sought in any science program that is truly functional.

Variety adds interest to education. Although the units in the following pages have a common structure, good teaching will supply the variety in pupil planning and activities that will maintain spontaneous enthusiasm rather than stereotyped practice.

SUMMARY

1. This course of study is flexible and permissive. It is intended to stimulate teachers to shift from ways of presenting content by recitation to ways of planning and guiding pupil learning activities.

2. The daily science recitation is a relic. Classrooms should be transformed from lesson-hearing rooms to learning laboratories.

3. The scope of science education is as broad as life itself. However, selection must be made on the basis of functional utility, frequency of application, cruciality, many-sidedness, and personal appeal.

4. Sequence lies in the needs and maturity of the learner as well as in the logic of content material. Psychological organization is more productive than bits of knowledge which do not possess wholeness or unity or functional value.

5. Organization around a sequence of functional knowledge, principles, and understandings is the most acceptable procedure.

6. Lateral enrichment to provide for emphasis of life objectives and learning activities is essential for valid teaching.

7. Direct group problem-solving activities on life problems that are critical for people will be part of any science program that is actually functional.

SUGGESTED READING

1. Beauchamp, Wilbur L., "Trends in Science Education." Unpublished address to the Science Curriculum Committee of Western Pennsylvania, Pittsburgh, Pa., April 1950.

2. Burton, W. H., *The Guidance of Learning Activities.* New York, Appleton-Century-Crofts, Inc., 1947.

3. Corey, Stephen F., "The Developmental Tasks of Youth," *The American High School.* New York, Harper and Brothers. 1946.

4. *Learning and Instruction,* Forty-ninth Yearbook, Part I, of the National Society for the Study of Education. Chicago, Ill., University of Chicago Press, 1950.

5. Peters, Charles C., *Foundations of Educational Sociology.* New York, The Macmillan Company, 1932.

6. *Science Education in American Schools,* Forty-sixth Yearbook of the National Society for the Study of Education. Chicago, Ill., University of Chicago Press, 1947.

LEARNING ACTIVITIES IN GENERAL SCIENCE

SECTION 1

SCIENCE IN THE JUNIOR HIGH SCHOOL

General science is a fusion of physics, chemistry, biology, geology, and astronomy around basic problems of living. The student gains an over-all picture of science as it affects his everyday life. It provides experiences which youth will need in solving the many problems that confront them. The student must be well acquainted with the laws of nature. He must work in a scientific manner. These behaviors will be developed if he has a meaningful life-experience science course.

Satisfactory life adjustment requires a critical and scientific foundation rather than mere opinion, superstition, or prejudice. This science education can be approached by providing a good foundation of functional information and understandings through actual inductive investigation by the student. The development of functional understandings and behaviors, rather than the acquisition of memorized knowledge, is the result of the re-creation of experience by the student. People learn what they do.

Effective teaching develops understanding of basic science principles which underlie phenomena and provides actual practice in applying

these principles to everyday life. It is not enough to know that disease is caused by microorganisms. Learning experience must focus this knowledge on disease prevention and on desirable behaviors. Science thus becomes functional.

Planning the Junior High School Science Program

For several years, a standing committee of the National Association of Secondary School Principals has been at work on the problem of curriculum development to the end that secondary schools can more effectively meet the Imperative Needs of Youth. In an interim report of the committee which appears in the *Bulletin* of the organization for March, 1947, Dr. J. Paul Leonard, President of San Francisco (Cal.) State College, presented a useful basis for curriculum planning in science instruction:

"Every pupil who graduates from the high schools of today must realize the importance of science and its effect upon his personal, economic, and social life. Through science he will be brought into closer contact with the things of everyday life; he will derive an insight into the nature of scientific processes with which he comes into contact in the pursuit of his career; and he will acquire knowledge and understanding of those things necessary for his health and comfort. As a result of this study, he should be better able to adjust himself to his environment and contribute to the improvement of society as a whole."

Values for the Teaching of General Science

Among the functional values of general science are the following: (1) encouragement of a healthy curiosity about one's environment; (2) finding a reasonable explanation for happenings; (3) development of self-confidence; (4) development of a willingness to collect facts and from them to generalize with care, to suspend judgment when insufficient facts are available, to act upon propositions or suggestions when they are supported by a reasonable amount of data, and to change one's mind when new findings seem to warrant it; (5) development of the behaviors which apply scientific principles to daily living; (6) elimination of superstition; (7) development of salable skills; (8) formation of one's own personal viewpoint on life; and (9) development of a point of view that is broad and tolerant.

The Scope of General Science Instruction

On the basis of the principles just enumerated, the work in science falls into two major divisions. The first division has to do with *developing an understanding of the meaning and implications of science* throughout the entire curriculum of the school. The second has to do with that

specific area of experience commonly called science. In the school, no organization of science into specific courses is made before the tenth year. Throughout the elementary school and the junior high school, materials and methods of science are constantly introduced as they affect the problems studied by the child. Major courses are designed to acquaint the pupil with his community and with the need for understanding and acquiring certain types of behavior. The experience of the scientist and the findings of the laboratory are thus translated into human improvement.

In the junior high school, time is devoted to pupil-teacher study of problems that are socially and scientifically significant. There is no clear-cut division between the social and scientific aspects of the problems. Students and teacher generally develop a number of problems or units that seem to meet the needs and interests of the pupils during these years. The assumption is made that no individual meets problems in everyday situations that are divided into social problems and science problems.

When the pupil enters the ninth grade, he begins to look at science as a special field of study, but he continues to consider it as related to the common problems of living. In a course in general science, pupils do not spend much time trying to discover what chemistry is, what physics treats, and what biology deals with. They get at the heart of certain basic problems which are of concern to them and for which science has a contribution or some explanation or assistance to give. Basically, they study their own bodies, the nature of their own growth and development, the factors involved in the maintenance of health, both public and personal, the nature of disease and of medical treatment, the nature of food and its relationship to the building of the body, exercise, sleep, recreation, the requisites of good mental health, and the physiological changes that take place as adolescence and maturity reach them. They also make a careful study of the problem of resources, beginning to understand that the wealth of the nation depends upon the amount and the utilization of its resources. They study their own community and their nation, and begin to understand the relationships between the nations which have abundant resources and those which do not.

Science vs. Quackery and Omens

In addition, pupils begin to apply certain scientific knowledge to modern pseudo-science or scientific vagaries, such as phrenology, graphology, palmistry, numerology, occultisms, horoscopes, prophecies, Ouija boards, hoaxes, perpetual motion, water lore, charlatanism, quackery, fallacies, frauds, mediums, and clairvoyance.

Pupils are interested in superstition. They consider such things as ways to wish; weather prophets; or luck; or portents; or Dan Cupid;

raising an umbrella in the house as cause of bad luck; sneezing (some people believe it brings bad luck to sneeze before rising in the morning); card fortunes, dreams, belief in the power of certain numbers (the value of the number three or seven and the bad omen of number thirteen); and all kinds of omens of bad luck, death; and other such popular delusions.

To meet student needs and objectives of science education, the following sequence for grades seven, eight, and nine is presented. This sequence is suggestive. Teacher initiative and the unique needs of pupils, classes, and schools may lead to other more functional emphases.

GENERAL SCIENCE

GRADE SEVEN

Scope

The course in the seventh grade is designed to acquaint the student with modern scientific discoveries and how they directly influence his everyday life. It begins with a comparison of his home, travel, communication, and products of yesterday and today. This will show the immediate value of science and will stimulate a curiosity for the needs of the future. The student learns how to maintain good health, to value and care for both plants and animals, to use methods of conservation, to understand fundamental facts concerning the solar system, and to use biological resources for better living.

The suggested unit outlines are intended to stimulate further teacher and pupil-teacher planning. Additional time, which will be available, may well be devoted to life problems which are concerned with the full range of scientific experience.

Sequence

Unit	I	How Does Scientific Discovery Affect Our Lives?
Unit	II	How Can I Keep Healthy?
Unit	III	The Weather, What Can We Do About It?
Unit	IV	How Can We Conserve Our National Wealth?
Unit	V	Time, Measurement and Mass Production.
Unit	VI	The Solar System in Which We Live.
Unit	VII	Science in Our Homes.
Unit	VIII	How Can We Use Our Biological Resources for Better Living?
Unit	IX	Life Problem Unit: How Can I Heat and Ventilate My Home?
Unit	X	Life Problem Unit: What Should We Know About Heredity?

Evaluation

For the evaluative procedures which should be used at the termination of each unit, the user of this bulletin is referred to Section I of Chapter II, "Teaching Science by Units," and to Chapter IV, "Evaluation." Cooperative teacher-pupil evaluation and direct drill techniques, where needed, should be characteristics of all good evaluation. Sample pupil check lists are included for this purpose.

Unit I

HOW DOES SCIENTIFIC DISCOVERY AFFECT OUR LIVES?

1. *Overview: (by teacher)*
2. *Teacher-pupil planning: (group discussion)*
   a. What do we know now? (list on blackboard)
   b. What do we need to find out? (list on blackboard)
   c. What work plan shall we use? (list committees for reports)

Content	*Objectives*	*Learning Experiences and Reports*
1. Homes of yesterday and today: a. Furniture b. Architecture c. Appliances d. Lighting e. Handcrafts vs. mass production 2. Travel in America: a. From covered wagons to automobiles b. Sailboats to ocean liners c. Airplanes to jet planes d. Improvement of railroad trains 3. Communication and laws protecting communication: a. Mail b. Telephone c. Radio d. Telegraph 4. Manufacturing methods and products: a. What is meant by *synthetic?* b. What is nylon made of? c. What are plastics made of? 5. Other content and problems suggested by the class	1. To appreciate modern home equipment 2. To realize the rapid advancement in travel in the past few years 3. To have a better appreciation of communications 4. To be familiar with the new products on the market and the methods of production 5. To find out about the new terminology, such as video, synthetics, etc. 6. To understand how standards of living have improved under the free enterprise system 7. Other objectives developed by the class	*By class or committees* 1. Exhibit samples of weaving 2. Scrapbook of daily science news found in the newspapers and magazines 3. Collect or prepare models of covered wagon, airplanes, sailboats, trains, etc. 4. Visit a telephone exchange, an antique shop, a museum 5. Check the postal rates and make stamp collections 6. Collect plastics, new materials, such as nylon 7. Study solar heating *Other activities developed by the class* *Textbook study and use of reference materials* *Teaching films and exhibits* *Evaluation:* a. See page 70 of this section and Chapter IV b. Achievement test c. Self-appraisal *Direct teaching where needed*

Student Self-Appraisal Check List for Unit I—How Does Scientific Discovery Affect Our Lives?

The following self-evaluative check list may be mimeographed and given to the student in order that he may have a share in appraising his own learning. The student's self-evaluation may well be followed periodically by individual teacher-pupil conferences. Similar check lists for subsequent units can easily be prepared by the teacher.

To the student:

This list is intended to help you judge how much you are learning. Check each item very carefully, YES, D—doubtful, or NO. Do not check YES unless you know and know that you know.

1. *Useful Knowledge*

	Yes	D.	No
a. Can you compare the homes of yesterday and today with respect to: (1) furniture, (2) architecture, (3) appliances, (4) lighting, (5) handcrafts?			
b. Can you trace the development of transportation?			
c. Can you discuss the development of communication: (1) mail, (2) telephone, (3) telegraph, (4) radio?			
d. Can you explain how manufacturing methods and products have developed: nylon, plastics, etc.?			
e. Do you understand how the free enterprise system has promoted scientific and industrial progress?			

2. *Vocabulary*

Can you explain and use the following words?

	Yes	D.	No		Yes	D.	No
a. environment .				f. hypothesis . . .			
b. energy				g. latitude			
c. fungus				h. longitude . . .			
d. humidity				i. synthetic			
e. hard water . .				j. video			

3. *Principles and Laws*

Can you name four scientific principles or laws which explain any of the following daily activities? What makes men do these things?

Wearing clothes, building houses, making furniture, lighting homes

1. ____________ 3. ____________
2. ____________ 4. ____________

4. *Daily Activities and Phenomena*

Can you name four daily activities or phenomena which illustrate any of the following scientific principles or laws:

Electricity passing through a wire, the wheel and axle, plastics, electric waves in the air

1. ____________ 3. ____________
2. ____________ 4. ____________

	Yes	D.	No
5. Can you describe with a diagram what keeps an airplane flying in the air?			

6. What else did you learn in this unit?
7. What help did you give in what the class did?

UNIT II

HOW CAN I KEEP HEALTHY?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. The body-machine and its use of food: a. Cell—the building block of life b. Digestion c. Absorption	1. To understand why periodical health tests are necessary	1. Experiment showing the process of osmosis
2. Disease: a. What are germs? b. Communicable diseases can be spread c. Cures for diseases d. Preventives e. Noncommunicable diseases f. How does the body fight disease? g. Modern medicines enter the fight against disease	2. To know simple symptoms of disease	2. Make a scrapbook of types of foods
3. What health problems exist in the class?	3. To realize the importance of good health rules	3. Check on the results of the school health tests
4. Other content and problems suggested by the class	4. To understand what causes disease and how diseases may be prevented	4. Give biographies of some of the scientists who made discoveries in medicine
	5. To understand how the body fights disease	5. Check on the methods used to sterilize dishes, etc., used in hospitals and restaurants
	6. To know the names of modern drugs	6. Care of the Sick Booklet
	7. To study narcotics and alcohol	7. Address by health officer or school physician
	8. To understand what vocations are available in the field of health	8. Visit sewage disposal plant
	9. To study, by confidential survey, what health problems pupils have	9. Visit city dump
	10. Other objectives suggested by the class	10. Survey the pupils in the class for immediate health problems. Have group discussion and individual conferences
		Other activities suggested by the class.
		Evaluation: (See p. 70.)
		Direct teaching where needed

Student Self-Appraisal Check List for Unit II—How Can I Keep Healthy?

1. *Useful Knowledge*

	Yes	D.	No
a. Can you describe a simple cell?			
b. Can you explain what happens during digestion?			
c. Do you know what foods to eat for a well-balanced meal?			
d. Can you explain the nature of germs and bacteria?			
e. Do you follow good rules for avoiding disease?			
f. Can you name the organs of the body on a chart?			
g. Is there good sanitation in your community?			
h. Do you help to keep your school clean?			
i. Do you know how the health rate in your community compares with other communities?			

2. *Vocabulary*

Can you explain and use the following words?

	Yes	D.	No		Yes	D.	No
a. calorie				f. pasteurization			
b. carbohydrate				g. protein			
c. diet				h. protoplasm			
d. disinfectant				i. quarantine			
e. infection				j. red corpuscle			

3. *Principles and Laws*

Can you name four scientific principles or laws which explain any of the following daily activities?

immunizations, sanitation, disinfection, state clinics, use of soap and cleansers, eating proper foods

1. ______
2. ______
3. ______
4. ______

4. *Daily Activities and Phenomena*

Can you list four other daily activities or things which illustrate any of the following?

killing germs, hygiene, inoculation, nutrition, pollution, pasteurization, contamination, antiseptic

1. ______
2. ______
3. ______
4. ______

5. *Can You Prove by Demonstration or Experiment*

	Yes	D.	No
a. That germs exist?			
b. That germs can be killed?			
c. That house flies carry disease?			
d. That a well-balanced diet is necessary for health?			
e. That health is a common problem for all people?			

6. What else did you learn in this unit?

What help did you give to what the class did?

UNIT III

THE WEATHER, WHAT CAN WE DO ABOUT IT?

Overview by teacher and planning with pupils

Content

1. The Atmosphere
   a. Effects of weather on everyday life
   b. United States Weather Bureau
   c. Properties of air
      (1) Altitude
      (2) Air pressure
   d. Water in the air
      (1) Cloud types
      (2) Condensations
2. The air masses
   a. General air movements
   b. Origin of storms
3. Can we control the weather?
   a. Adaptations to weather
   b. Attempts at weather control
      (1) Silver iodide
      (2) Carbon dioxide
      (3) Stopping destructive hailstones
   c. The future of weather control
      (1) Artificial lakes
      (2) Irrigation projects
      (3) Changing ocean currents
      (4) Shelter belts and forests
4. Other content and problems suggested by the class

Objectives

1. To understand what causes storms
2. To do away with incorrect weather superstitions
3. To realize how effectively man has adapted himself to various weather conditions
4. To learn how the Weather Bureau functions and how weather predictions save valuable food crops
5. To explore vocational possibilities
6. Other objectives selected by the class

Learning Experiences and Reports

By class or committees

1. Make a barometer and check pressures
2. Collect pictures showing cloud types
   Observe clouds from school windows
3. Draw several patterns of snowflakes
4. Make a hygrometer and check the readings daily
5. Make a physical map—locate the major deserts of the world
6. Check weather beliefs
7. Air conditioning
8. Check how weather affects air travel, etc.
9. Visit an airport
10. Have a weather man speak to students

Other activities suggested by the class

Study text and reference materials

Evaluation: (See p. 70.)

Direct teaching where needed

UNIT IV

HOW CAN WE CONSERVE OUR NATURAL WEALTH?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
1. Forests are crops a. Paper, synthetics, airplanes b. Forests stop erosion c. What is happening to our forests: Fire, insects, disease, lumbering practices d. Methods of keeping our forest wealth 2. Should we be concerned about wildlife? a. Wildlife is an important source of wealth b. Hunting and fishing restrictions c. Individuals must help d. Government aid 3. Topsoil, our most important resource a. Life in the soil b. Soil conservation 4. Other content and problems suggested by the class	1. To awaken everyone to the rapid loss of our natural wealth 2. To obey all game laws 3. To understand how to conserve our wealth 4. To realize money must be spent to reclaim land and restock our wildlife 5. To learn the way to enjoy a vacation and care for the recreation area for another year 6. To explore the vocational opportunities in conservation and the education required 7. Other objectives suggested by the class	*By class or committees* 1. Visit land reclamation project 2. Visit the State fish hatcheries 3. Study methods of farming in the region 4. Plant seeds and watch growth 5. Make a list of places where extensive soil erosion is taking place 6. Learn the hunting and fishing laws 7. Make a list of the many forest products 8. Plant several trees 9. Report on duties by a Forest Ranger 10. Talk to class by a Farm Agent 11. Class trip to a woods. Collect leaves *Other activities suggested by the class* ***Textbook and reference study*** *Evaluation:* (See p. 70.) ***Direct teaching where needed***

Student Self Appraisal Check List for Unit IV —How Can We Conserve Our Natural Wealth?

1. *Useful Knowledge*

	Yes	D.	No
a. Do you know how much of Pennsylvania is forest?			
b. Do you know where in Pennsylvania there are virgin forests?			
c. Can you locate the Pennsylvania State Forests on a map?			
d. Can you identify ten kinds of Pennsylvania trees?			
e. Can you describe how soil erosion can be prevented?			
f. Do you know the job opportunities, educational requirements, and pay for work in conservation?			
g. Can you identify ten kinds of birds in Pennsylvania? Ten kinds of furry animals?			
h. Are you familiar with Pennsylvania's fish and game laws?			
i. Do you know how to plant a tree?			
j. Can you discuss flood control and stream clearance in Pennsylvania? In your community?			

2. *Vocabulary*

Can you explain and use the following words or terms?

	Yes	D.	No		Yes	D.	No
a. biology				f. plateau			
b. conservation				g. pollen			
c. humus				h. species			
d. loam				i. spore			
e. parasite				j. transpiration			

3. *Principles and Laws*

Can you name four scientific principles or laws which explain any of the following daily activities? Why are these things done?

soil erosion and control, 1. ______________________
forest and flood control, 2. ______________________
reforestation, work on stream 3. ______________________
clearance, fire prevention 4. ______________________

4. *Daily Activities and Phenomena*

Can you name four daily activities or facts which illustrate any of the following?

The resources of nature are limited. 1. ______________________
Man must control insects in order to live. 2. ______________________
Scientific agriculture has made possible population increases. 3. ______________________
4. ______________________

Man has made substitutions for resources that are being exhausted.

People go hungry in countries that do not practice conservation.

UNIT V

TIME, MEASUREMENT, AND MASS PRODUCTION

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Precision demands in modern production a. New metals b. Interchangeable parts c. Advantages of standardized parts	1. To realize that industry is traveling at a fast pace and that the worker must adjust to this added strain	1. Use the metric system of measurement
2. Measurements in industry a. Electricity—meters b. Chemistry—balance c. Physics—metric and English system d. Liquid, solids, gas measurements e. Bureau of Standards	2. To realize that as labor-saving devices shorten time needed for production, the worker will need to find more recreation	2. Learn how to read an electric meter and to figure the cost of a bill
3. Time in the modern world a. Transportation demands precision b. Communication c. Physician and urgency of time d. Time demands a system	3. To recognize the value of standard interchangeable parts	3. Measure a room—show the differences in answers
4. Mass production a. Assembly line b. Mental strain c. Cooperation in production d. Arts vs. mass production e. More leisure time	4. To find out how to make precision measurements	4. Plan a trip by air and train, checking time
5. Other content and problems suggested by the class	5. To understand the relationship of measurement to civilization	5. Draw a chart showing how each student spends his time during a day
	6. To gain an appreciation of the value of time and motion study	6. Plan a job with each student having a special part to do. Then have each student do every part of the job
	7. To realize the effect of free enterprise on production	7. Talks to class by a surveyor or an engineer
	8. To understand the relationship of time and measurement to the student	8. Visit the school boiler room. Inspect meters and gauges
	9. To learn about vocational opportunities	9. Measure the capacity of variously numbered cans
	10. Other objectives suggested by the class	10. Make a time study of a person doing work
		Other activities suggested by the class
		Study of text and reference material
		Evaluation: (See p. 70.)
		Direct teaching where needed

Unit VI

THE SOLAR SYSTEM IN WHICH WE LIVE

Overview by teacher and planning with pupils

Content

1. Beginnings of astronomy and of modern astronomy
2. The sun:
   a. What the sun is composed of
   b. How we have learned about the sun
   c. Sunspots
3. The earth:
   a. What the earth is composed of
   b. Rotation and revolution
   c. Location as determined on maps
   d. Standard time belts
   e. Causes of seasons
4. Moon, comets and meteors:
   a. What causes the phases of the moon?
   b. What keeps the moon and earth in place?
   c. Newton's Law of Gravitation
   d. Eclipses
5. Other planets
6. Stars and other heavenly bodies
7. Other content or problems suggested by the class

Objectives

1. To appreciate the relationship between the sun, earth, and planets
2. To understand the reason for seasons and the four time belts in the United States
3. To understand the reasons for the phases of the moon
4. To understand how an airplane is navigated
5. To learn about the constellations
6. To appreciate the work of Galileo, Herschel, Newton
7. To dispel superstition
8. Other objectives suggested by the class

Learning Experiences and Reports

By class or committees

1. Show the sun's spectrum
2. Demonstrate the phases of the moon with a bright light shining on a large globe.
3. Demonstrate a lunar eclipse.
4. Visit a museum exhibit of meteorites.
5. Make a graph showing amount of daylight for the seasons.
6. Make a star chart.
7. Report on planetariums.
8. Have an airplane navigator speak to the class.
9. Observe the moon each morning and evening for a month. Make a chart showing its location, shape, time of rising and setting.
10. Make a star box, a simple planetarium.

Other activities suggested by the class

Teaching films and exhibits

Study of text and reference materials

Evaluation: (See p. 70.)

Direct teaching where needed

UNIT VII

SCIENCE IN OUR HOMES

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Heating our homes: a. Solar heating b. Air conditioning c. New-type furnaces give more heat with less fuel	1. To realize what the home of tomorrow will be	1. Obtain booklets on air conditioning
2. Lighting our homes: a. Methods of lighting: (1) Mercury vapor lamps (2) Ultra-violet lamps (3) Fluorescent lamps	2. To be ready to accept the new appliances intelligently	2. Study modern house design.
3. Electronics in our home: a. Audio and video radio sets b. Electronic heating c. Electronics in industry	3. To appreciate the advancements science has made	3. Visit radio store to see television
4. Sound in the home: a. Sound-proof insulation b. Telephone c. Hearing aids	4. To learn how to take care of scientific equipment in the home	4. Plan your house of tomorrow
5. New materials and designs: a. Plastics b. Glass fabrics c. Nylon	5. To learn simple rules for home safety	5. Plan a trip to the telephone company.
6. Selection of materials	6. To learn how to judge the best types of home appliances	6. Obtain information on hearing aids
7. Other content and problems suggested by the class	7. To learn about vocational opportunities.	7. Demonstrate how a partial vacuum stops sound waves
	8. To learn about proteins, starches, sugars, fats, food selection and cost, microbes as friends and foes	8. Make a booklet on modern design
	9. To understand the preparation of foods	9. Talk to class by an architect
	10. To understand cold storage	10. Talk to class by the home economics teacher.
	11. Other objectives suggested by the class	11. Talk to class by a radio man
		12. Visit to a broadcasting station
		Other activities suggested by the class
		Study of text and reference material
		Evaluation: (See p. 70.)
		Direct teaching where needed

Unit VIII

HOW CAN WE USE BIOLOGICAL RESOURCES FOR BETTER LIVING?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Kinds of living things a. Animals with backbones b. Spineless animals c. Kinds of plants d. Microscopic plants and animals	1. To be able to recognize the various animals in their habitats	1. Field trips
2. Plants' and animals' adaptations to seasons	2. To learn ways and means that animals have for protection	2. Study butterfly metamorphosis
3. Products of plants and animals	3. To learn that there is a definite balance of plants and animals in nature, as well as interdependence	3. Study spider web
4. Pennsylvania's crops and flowers	4. To realize that bacteria are both useful and harmful	4. Watch a crayfish walk, swim, and capture food
5. Pennsylvania's wildlife	5. To understand how plants and animals survive the winter season	5. Obtain land snails. Observation and feeding of snails
6. Influence of the environment on the forms of life	6. To learn about protective devices of plants—spines, leaves, bark, color, odor, etc.	6. Observe earthworms
7. Dependence for survival upon the ability to adapt	7. To learn how to feed and care for farm animals and pets	7. Watch the development of tadpoles
8. Law of the survival of the fittest	8. To learn how to identify growing crops and flowers	8. Maintain a balanced aquarium and terrarium
9. Man as a determining factor of environment	9. To learn about vocations in this area	9. Have an ant colony. Observation and feeding of ants
10. Other content and problems suggested by the class	10. Other objectives suggested by the class	10. Build birdhouses
		11. Grow mold and view under a microscope
		12. Show how plants are affected by light
		13. Make a products chart for plants and animals
		14. Talk to class by a naturalist
		Other activities suggested by the class
		Study text and reference material
		Evaluation: (See p. 70.)
		Direct teaching where needed

UNIT IX—A LIFE PROBLEM UNIT

HOW CAN I HEAT AND VENTILATE MY HOME?

I. OVERVIEW BY TEACHER AND PLANNING WITH PUPILS

Objectives:

1. To develop an appreciation of the importance of air in healthful living
2. To gain an understanding of the different ways in which fire is used for heating purposes
3. To know that the sun is the source of heat and that heat travels in waves with the help of matter and by convection and conduction by means of matter

II. CONTENT

A. *How Heat is Produced:*
   1. Most important source
   2. Chemical change
   3. Friction
   4. Electrical current

B. *Volume of Matter May be Changed:*
   1. Contraction and expansion
   2. Thermostat
   3. Weight of water

C. *Measuring Temperature:*
   1. Temperature
   2. Thermometer
   3. Units used

D. *Stove or Heater:*
   1. Provides own draft
   2. Air supply

E. *Heat Transfer:*
   1. Radiation of heat
   2. Conduction of heat
   3. Convection of heat
   4. Hot air furnace
   5. Hot water heating
   6. Steam heating
   7. Advantages and disadvantages of each
   8. Fuels

F. *Fuel Waste:*
   1. Ways wasted
   2. Smoke
   3. Nonconducting materials
   4. Radiators and reflectors
   5. Boiling water
   6. Thermos bottle

G. *Heated Home:*
   1. Ventilating system

III. ACTIVITIES

A. *Preview Questions*
   1. How did the ancient people heat their homes?
   2. What fuels did they use?
   3. When and and by whom was the stove invented?
   4. What are the different sources of heat?
   5. What are the effects of heat on matter?
   6. How do stoves and furnaces help to provide a continuous supply of fresh air?
   7. What is the purpose of a Bunsen burner?
   8. How is heat transferred from one place to another?
   9. How is temperature measured?
   10. Why is it necessary to ventilate homes?
   11. How may fuels be burned more efficiently?
   12. What are the different units of heat?
   13. What are the possible developments in the heating of homes?

B. *Problem Situation*

1. Heat is measured by light, chemical change, friction, and electrical currents:
   a. How may the different forms of energy be converted into heat energy?
   b. What energy changes go on in your home?
   c. What energy changes go on in the school?

2. The volume of matter may be changed by heating and by cooling:
   a. In general how do heating and cooling of gases, liquids, and solids affect volume?
   b. Explain the construction and operation of the thermostat.
   c. At what temperature does water expand, whether cooled or heated?
   d. How is the expansion of water allowed for in an automobile radiator?
   e. How are contraction and expansion allowed for in cement roads and sidewalks, in the laying of steel rails, and in bridges?
   f. Why are telephone wires "tighter" in winter than in summer?

3. Temperature is measured in degrees.
   a. Why is the sense of feeling not reliable enough for taking temperatures?
   b. How are thermometers made?
   c. How are the fixed points on the Centigrade and Fahrenheit scales obtained?
   d. What is a B.T.U.?
   e. What is a small calorie?
   f. What is a large calorie?
   g. What is the meaning of temperature?

4. In a stove or heater, air is supplied to the burning fuel and the products of combustion are removed:
   a. What is a draft?
   b. What are dampers?
   c. How does a Bunsen burner mix air and gas?
   d. Under what conditions is smoke produced?
   e. How are the drafts set when a fire is started?
   f. How are the drafts set when you want to check a fire?

5. Heat is transferred from place to place by radiation, convection, and conduction:
   a. What are the three methods in which heat may be distributed?
   b. Give an example of each method.
   c. Name three good conductors.
   d. Name three poor conductors.
   e. Compare the hot air, hot water, and steam heating systems.
   f. How does each distribute heat?
   g. What are the advantages and disadvantages of each system?
   h. How is oil burned?

6. Fuel is wasted through poor construction and faulty regulation of stoves and heaters:
   a. Why is it dangerous to close the dampers too tightly at night?
   b. Why do motorists sometimes lose their lives by remaining in a closed garage with the engine running?
   c. Why are leaky and mismanaged ranges and furnaces dangerous?

d. In what ways may fuel be wasted with a stove or heater?
e. What is smoke?
f. Under what conditions is smoke formed?
g. How may the walls of a house be constructed to prevent loss of heat?
h. What type of material makes a good radiator?
i. Why should the gas be turned low under a kettle after potatoes have started to boil?
j. How is loss of heat by conduction, convection, and radiation prevented in a thermos bottle?

7. A heated home needs circulating air and moisture.
   a. What is the meaning of ventilation?
   b. How is air made to circulate?
   c. How is water added to the air?
   d. When is air impure for breathing purposes?

C. *Experiments*

1. How heat is produced
2. Contraction and expansion
3. Degree of heat
4. Thermometers
5. Unit of heat
6. Chimneys
7. Drafts and dampers
8. Bunsen burners
9. Radiation
10. Convection
11. Steam heating
12. Smoke
13. Nonconducting materials
14. Reflectors
15. Ventilation
16. Impure air

D. *Review*

1. Be able to pronounce, spell, and use correctly the following words:

temperature	thermostat	energy
friction	calorie	thermal
Fahrenheit	Renault	Centigrade
Bunsen	convection	radiation
conduction	reflection	thermos
insulating	ventilate	combustion
air conditioning	expansion	contraction

E. *Additional Suggestions for Individual Work*

1. Compare the methods used to produce heat now with the methods used in ancient times.
2. What is the effect of a change in temperature on the volume of liquids, solids, and gases?
3. At what temperature does water have its greatest weight per cubic foot?
4. How is the schoolroom ventilated?
5. How are air and gasoline mixed in a gasoline engine?
6. Why has man been able to live anywhere on the earth during all seasons?
7. What is cold?
8. How is the air made "twenty degrees cooler" inside theaters?
9. Name as many different types of heating apparatus as possible.
10. Can you work hard in a hot stuffy room?
11. Name some ways of producing heat without using fire.
12. Does extreme cold affect your penmanship?
13. What are the different methods of insulation?
14. Give several methods of warming your hands while coasting or ice skating.

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Reisbeck, E. W., *Air Conditioning*. Chicago, Illinois, Goodhart-Wilcox Co., 1939

Peet, C., *This Is the Way We Build a Home*. New York, Henry Holt & Company, Inc., 1942

Black, N. H. and Davis, H. N., *Elementary Practical Physics*. New York, The Macmillan Company, 1949

Dull, C. E., *Modern Physics*. New York, Henry Holt & Company, Inc., 1949

G. *Visual Aids*

Motion pictures

1. Films available on:
   Anthracite Coal—silent
   Hot Air Heating—silent
2. Films available from other sources:
   Chemistry of Combustion—sound
   Projected Visual Aids, Inc.
   6050 Broadway, Chicago, Ill.

IV. PROBABLE OUTCOMES

A. *Attitudes*

1. An appreciation of the great economic importance of heat to man
2. An understanding of the ways in which man has improved methods of using and controlling fire

B. *Skills*

1. To become acquainted with the common fuels used either in the home or in industry
2. To gain an understanding of expansion and contraction and how they affect the behavior of solids, liquids, and gases
3. To know the three requirements of burning, i. e., oxygen supply, combustible materials, and kindling temperatures

C. *Generalizations*

1. Heat may be produced mechanically, chemically, electrically
2. Heat is a form of energy
3. Conservation of fuel depends upon the knowledge of methods of heating and insulation

A PICTURE IS WORTH MANY WORDS

Unit X

WHAT SHOULD WE KNOW ABOUT HEREDITY?

I. OVERVIEW BY TEACHER AND PLANNING WITH PUPILS

II. CENTRAL OBJECTIVES

A. To understand the problems of reproduction and heredity

B. To learn about the complexes of living genes as the source and foundation of human thought and action

C. To realize the significance and problems of adolescence

III. CONTRIBUTING OBJECTIVES

A. Personal adjustment:

1. Personal research and inductive reasoning

   Of all the various topics covered in a year's time, this is the subject most likely to give the greatest motivation

2. Emotional stability

   To contribute to the adjustments and developmental tasks of adolescence

3. Physical defects

   To understand how physical defects occur whether they are received from one's ancestors or whether they are the product of the environment. After the tracing of the source, what can be done about them?

4. Mental cleanliness

   To stress that an unclean mind is a sign of an unhealthy mind

B. Adjustment to Bodily Growth:

1. Oral expression

   To realize that it is right to talk of birth and one's birthright. These subjects should he expressed with honesty. Any suggestion of "hush" or "silent" talk suggests that nothing but wrong is associated with this subject.

2. Overcome defensive attitudes

   To discover that a defensive attitude is one formed from one's environment and therefore may be changed.

3. Growing up

   Pupils have reached the age when childhood appears, or should appear, as passing. This is the time to grow and assume a place in the world. From the subject there should be brought to attention:

   (a) What factors for survival pupils were or were not born with

   (b) What factors for survival pupils have learned or have failed to learn from their environment.

   If both factors of heredity and environment have not been too kind to them, what are they going to do to fortify themselves for life and the struggle for existence?

C. Social Adjustment and Citizenship:

1. Self-discipline

   To realize that self-discipline, like so many other learnings already mentioned, is self-learned or self-taught, and that one's inheritance helps little.

2. Ability to make friends easily

   To find out this also is a factor to be learned and at no other time in their lives can they better cultivate new habits or form new and better friendships.

3. Adjustment to changing conditions

   To understand that in the organic and inorganic world nothing is more constant than change. Yet, nothing is more basic to life itself and the sooner one accepts change the sooner one can move toward a happier life.

IV. LEARNING ACTIVITIES

A. For the objectives, the following meaningful learning experiences should be planned and carried out

1. Student round-table discussions, forums and debates

   In no other topic is it easier to stimulate discussions. The teacher should not pass over these opportunities lightly; they appear to arise from a sincere seeking of knowledge due to the particular age of the group.

2. Guest speakers

   Well-qualified speakers. An outsider—a community doctor, or a nurse—seems to carry more weight with the students than the instructor.

3. Student surveys and class projects

   Graphs, charts, tabulations, etc., can be done in and out of class concerning eye color, hair color, height, dominant and recessive characteristics. Outside projects on individual leaf color, number, side, shape, pattern, etc. (These possibilities are endless.)

4. Visual materials
    a. Charts: family trees, pedigrees of dogs, cats, horses, pigs, humans, etc.
    b. Slides: cells of chromosomes and genes. This is all microscopic work if the microscopes are available.
    c. Mounted pictures: the birth of a child, periods of gestation, twins, multiple births, freaks, mutations and mutants, hybrids, evolutionary trees, inheritable characteristics both good and bad in respect to marriage.
    d. Recordings: mating calls of various animals.
    e. Sound film: "Human Growth," from Pennsylvania Medical Society, Harrisburg.

B. The following are the possible field trips that could be incorporated into this unit. They are copied from the list suggested by a class committee.

1. Planetarium
2. Conservatory
3. Museum
4. Zoo
5. City hospital
6. Cook Forest State Park
7. State institutions (mental)
8. County courts, juvenile courts, court house, detention homes, etc.
9. School for the blind
10. School for the deaf
11. Livestock show or fair
12. Farms

V. CULMINATING ACTIVITIES

Pupil displays, reports, exhibits, etc.

VI. EVALUATION

A. Have the central and contributing objectives been achieved? This may be determined by

1. A functional unit test on information
2. A test of generalizations. See Chapter IV, "Evaluation"
3. Student questionnaire on attitudes
4. Group discussion

B. Have pupil committees worked well together? Group discusssion.

FIRSTHAND EXPERIENCE

GRADE EIGHT

Scope

The course in the eighth grade develops a more detailed approach to the principles of science that deal with plants, air, water, heat, sound, elements, and compounds. Many of the experiments suggested may be demonstrations rather than individual experiments. The former are more desirable.

Students can do many experiments at home and at school that do not involve much expense or demand expensive equipment. People learn what they do. The content and experiences should be fitted to the needs of the individual school and of the individual pupils.

Sequence

UNIT I: How Do We Raise and Use Plants?
UNIT II: How Do We Use the Air?
UNIT III: How Is Our Water Supply Kept Safe?
UNIT IV: Some Effects of Heat
UNIT V: What Should We Know About Sound?
UNIT VI: Earth's Changing Surface
UNIT VII: How Does My Body Work?

UNIT VIII: Elements and Compounds
UNIT IX: Life Problem Unit: How Can We Force Water to Serve Our Needs?
UNIT X: A Journey: Our Class Visits the Filtration Plant

Evaluation

For the evaluative procedures which should be used at the termination of each unit, the user of this bulletin is referred to Section 1 of Chapter II, "Teaching Science by Units," and to Chapter IV, "Evaluation." Cooperative teacher-pupil evaluation and direct drill techniques, where needed, should be characteristics of all good evaluation.. Pupil check lists for self-evaluation can be readily constructed. A sample is included for Unit V, "What Should We Know About Sound?"

Unit I

HOW DO WE RAISE AND USE PLANTS?

1. *Overview: (by teacher)*
2. *Teacher-pupil planning: (group discussion)*
   a. What do we know now? (list on blackboard)
   b. What do we need to find out? (list on blackboard)
   c. What work plan shall we use? (list committees for reports)

Content	*Objectives*	*Learning Experiences and Reports*
1. Parts of a plant and division of labor to each part 2. Photosynthesis makes plants independent: a. Protoplasm the substance of every cell b. Plants get their food from the soil Osmosis and transportation 3. Our farms and their crops Products of the farm a. Rayon b. Soy beans c. Hydrogenated plant fats d. Plastics e. Paper, etc. 4. Government aids for agriculture a. Weather Bureau b. Soil analysis c. Production of new strains of cattle, plants, etc. d. Study of insect control 5. Conservation of the soil Rapid rate of soil erosion 6. Other content and problems suggested by the class	1. To appreciate the beauty of plants 2. To know the products obtained from plants and how much we are dependent on the farms 3. To know how plants reproduce and how plants germinate from seeds 4. To recognize the immediate need for scientific farming and soil reclamation projects 5. To realize that life depends on the sun 6. To learn about opportunities for earning a living 7. Other objectives suggested by the class	*By class or committees* 1. Collect a museum display of products from the farm 2. Study types of insect controls 3. Study the parts of a plant: roots, stems, leaves, flowers and seeds 4. Methods of soil conservation 5. Study government aids 6. Controlled experiments on plant growth as to light, water, heat 7. Hydroponic experiments 8. Trace the transportation system using colored ink. Osmosis *Other activities developed by the class* *Textbook study and use of reference materials* *Teaching films and exhibits* *Evaluation* a. See Chapter IV b. Achievement tests c. Self-evaluation *Direct teaching where needed*

UNIT II

HOW DO WE USE THE AIR?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Properties of Air a. Composition b. Air has weight and exerts pressure (1) Diving bells (2) Submarines (3) Tunnels under the river (4) Automatic door check (5) Automobile tires (6) Air brakes c. Unbalanced pressure Machines, such as electric cleaner, siphon, pumps, parachutes, airplanes d. Partial vacuums used in our everyday life Devices such as thermos bottles, thermometers, fountain pens, inkwells, medicine droppers	1. Respect for the men who have given us the principles of air pressure 2. Use appliances intelligently 3. Modern progress in transportation is due to knowledge of the control and use of the air 4. Know how to prevent oxidation 5. Learn about vocations 6. Other objectives developed by the class	1. Iron filings in a test tube put in a glass of water to show the per cent of O_2 in the air 2. Measure air pressure 3. Visit airport—check landings and qualifications for a pilot 4. Biographies of Priestley, Lindbergh, Langley, Wright brothers 5. Make models of parachutes, planes, etc. 6. Make fire extinguisher 7. Study school furnace
2. Streamlining		*Other activities developed by the class* *Textbook study and use of reference materials*
3. Oxidation and its control: fire, rusting, explosives		*Teaching films and exhibits* *Evaluation:* (See p. 90.)
4. Other content and problems suggested by the class		*Direct teaching where needed*

Unit III

HOW IS OUR WATER SUPPLY KEPT SAFE?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Water: a. Composition b. Supply (rain makers) c. Water cycle d. Water table	1. An appreciation of the problems that must be considered to have a safe water supply	1. Experiments showing methods of purification
2. Purification methods of the city water supply: Filtrating, chlorinating, settling, aerating, distilling, boiling, bacterial purifying	2. Conservation of the water supply	2. Investigation of the water supply of the community
3. How to keep our streams pure a. Sewage disposal system a must (Act 177—1945, Pennsylvania General Assembly b. Restocking streams	3. Wise use of the sources of water to raise the economic standards of a community	3. Write to the Fish and Game Commission about fishing laws, sewage disposal, etc.
4. Water softeners and soap	4. Methods of sewage disposal are necessary if we are to have enjoyable recreation and safe drinking water	4. Test various soap products
5. Water power, unharnessed energy	5. Knowledge of how disease is spread by impure water	5. Visit an electric light company
6. Plumbing systems in our homes: Traps, meters, flush tank operation, cesspools, septic tanks	6. How we can tap the water supply to reclaim lands and gain vast supplies of hydroelectric power	6. Experiment on Archimedes' principle
7. Is my "vacation" plan protected by safe water, and how do we plan to take care of the water? a. Disease b. Purification c. Fishing	7. To learn about vocations	7. Make a manometer
8. Water can be controlled to do work a. Hydraulic devices b. Water wheels c. Hydroelectricity	8. Other objectives developed by the class	*Other activities developed by the class* *Textbook study and use of reference materials* *Teaching films and exhibits* *Evaluation:* (See p. 90.) *Direct teaching where needed*

Unit IV

SOME EFFECTS OF HEAT

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Methods of heat transfer and how they are used in heating our homes: a. Types of heating systems b. Methods of insulation c. Types of fuel d. Drafts and dampers e. Thermostats	1. To study the best methods and fuels for heating homes and ways to prevent fuel waste 2. To understand how to use appliances intelligently	1. Visit the school heating and ventilating system 2. Examine insulating materials 3. Construct a fireless cooker
2. Measuring temperature	3. To understand how temperature expands and contracts materials	4. Study methods for preventing heat loss
3. How does steam heat a room?	4. To learn about vocations	5. Check how a bridge is constructed to allow for expansion
4. Ventilation: a. Air conditioning b. How air can be cleaned	5. Other objectives developed by the class	6. Check the effects of a change in temperature on the volume of liquids, solids, and gases
5. How may the temperature be controlled? a. Vacuum bottles b. Ice box c. Electric refrigerator d. Deep-freeze units		*Other activities developed by the class* *Textbook study and use of reference materials* *Teaching films and exhibits*
6. Expansion and contraction due to temperature Bridge and road construction		*Evaluation:* (See p. 90.) *Direct teaching where needed*
7. Other content and problems suggested by the class		

UNIT V

WHAT SHOULD WE KNOW ABOUT SOUND?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. What is sound? a. Sound is a vibration b. Various mediums c. Echo is a reflected sound wave	1. To realize that sonics is a science 2. To develop a cooperative spirit in keeping all unnecessary noise at a minimum	1. Visit a radio studio 2. Discuss hearing aids 3. Study of musical instruments
2. How do we hear? a. The nervous system b. Hearing tests c. Hearing aids	3. To develop appreciation of music 4. To acquire a knowledge of modern everyday terminology, such as F M	4. Experiment of electric bell under a bell jar—vacuum 5. Make a voice recording
3. Is it noise or is it music? a. Types of musical instruments b. Soundproofing buildings c. How to get rid of noise in industry d. Noise and our health	5. To know the physical phenomena involved in hearing and the correct care of the ears and nerves 6. To understand that sound and the control of sound waves have much to do with our way of living	6. Demonstration of the school hearing test 7. Visit telephone exchange 8. Sound effects, using radio program script
4. The principles of sound that are applied in modern devices: a. Radar b. Radio sound effects c. Radio transmission d. Silent dog whistle e. Airplane landings f. Insect extermination	7. To learn how the principles of sound were used to our advantage in World War II 8. To learn about vocations 9. Other objectives developed by the class	*Other activities developed by the class* *Textbook study and use of reference materials* *Teaching films and exhibits* *Evaluation:* (See p. 90.) *Direct teaching where needed*
5. Other content and problems suggested by the class		

Student Self-Appraisal Check List for Unit V—What Should We Know About Sound?

1. *Useful Knowledge*

	Yes	D.	No
a. Do you know how sound is produced and how it travels?			
b. Do you understand how sound affects the ears?			
c. Can you explain how two sounds can produce silence?			
d. Can you explain how an automobile muffler works?			
e. Do you know what creates good acoustics in a theatre?			
f. Can you explain the difference between noise and music?			
g. Do you know how many intervals there are on an even-tempered scale?			
h. Do you know what maximum noise level is considered desirable in an office?			
i. Can you draw a diagram of a telephone transmitter and receiver?			
j. Can you describe the difference between pitch and loudness?			

2. *Vocabulary*

Can you explain and use the following words?

	Yes	D.	No		Yes	D.	No
a. beat				f. discord			
b. chord				g. echo			
c. chromatic scale				h. frequency			
d. decibel				i. note			
e. diatonic scale				j. octave			

3. *Principles and Laws*

Can you name six principles or laws which explain any of the following?

Singing, listening to music, speaking, bell ringing, whistling, radio, phonograph, telephone, sonar.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

4. *Daily Activities and Phenomena*

Can you list six other daily activities or phenomena which illustrate any of the followi

How sound is transmitted, volume of sound, absorption of sound, pitch, sympathetic vibrations, acoustics.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

5. *Can you demonstrate*

	Yes	D.	No
a. How to measure the speed of sound?			
b. Methods of noise control?			
c. How to measure distance by sound?			
d. The measurement of wave lengths?			
e. Overtones?			

6. What else did you learn in this unit?
What help did you give to the work of your class?

UNIT VI

EARTH'S CHANGING SURFACE

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
1. Ever-changing surfaces: a. Rocks to soil b. How valleys form c. How streams build land d. How did the Great Plains form e. The seashore forms f. Young and old mountains g. Why the layers of rock wrinkle h. Cause of earthquakes i. Glaciers j. Man changes the contour of the earth's surface k. Conservation of our soil 2. What the solid earth is made of: a. Inside the earth b. Do the continents float? c. How do rocks form? d. How can we tell the age of the earth? e. Economic value of the earth 3. The science of the sea: a. How deep is the ocean? b. What types of animals are found in the deep sea? c. Ocean currents affect climate d. What causes waves? e. Economic value of the sea f. How can we change salt water to fresh water? g. Why is the Great Salt Lake salty? 4. Other content and problems suggested by pupils	1. To appreciate natural forces 2. To realize soil is in the making and the problem of conservation 3. To recognize the economic dependence of the world on soil 4. To show that the sea is an untapped source of mineral wealth 5. To learn about vocations 6. Other objectives developed by the class	*By class or committees* 1. Field trips to study erosion, rock strata, strip mining, types of farming 2. Classify types of rocks and soil 3. Read the history of the land by fossils 4. Evaporate salt water to show that minerals are hidden in a solution 5. Visit a coal mine 6. Make a seismograph 7. Make model rock formations with plaster of Paris 8. Visit a reclaimed land project *Other activities developed by the class* *Textbook study and use of reference materials* *Teaching films and exhibits* *Evaluation:* (See p. 90.) *Direct teaching where needed*

Unit VII

HOW DOES MY BODY WORK?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. The body structure is built up of cells, tissues, organs, systems a. Parts of a cell b. How do we breathe? c. How does the blood circulate? d. How is food digested? e. How does the body get rid of wastes? f. How do the nerves control the body?	1. To realize health depends on correct diet 2. To understand how the body functions 3. To learn how to buy or prepare a well-balanced meal 4. To learn how to dress correctly for the seasons	1. Food tests 2. Write out a week's menu showing how a balanced diet can be maintained 3. Check fabrics for heat control 4. Make a chart on digestion 5. Experiments showing how we breathe
2. Do we have a well-balanced diet? a. Foods necessary for a well-balanced diet b. Calories e. Vitamins d. Milk e. Results of malnutrition	5. To realize the harm from smoking and from use of alcoholic drinks 6. To understand adolescence 7. To find out about vocations	6. Talk to class by school nurse *Other activities developed by the class* *Textbook study and use of reference materials*
3. Stimulants and narcotics; effect on the body a. Alcohol b. Tobacco c. Patent medicines	8. Other objectives suggested by the class	*Teaching films and exhibits* *Evaluation:* (See p. 90.) *Direct teaching where needed*
4. Correct dress and diet for the various seasons a. Materials used for clothing b. Seasonal diets		
5. Other content and problems suggested by the pupils		

UNIT VIII

ELEMENTS AND COMPOUNDS

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Matter is a substance that occupies space and has weight a. Elements found in home and their uses b. Compounds c. Mixtures	1. To realize what matter is made of 2. To understand how to use chemicals intelligently	1. Collect samples of elements, compounds, found in the home 2. Test products to determine if they are acids or bases 3. Make soap
2. Everyday use for acids, bases, and salts. a. Properties b. Tests c. Products	3. To know how to remove stains from household articles 4. To understand the importance of the scientist in the discovery of new materials in our everyday life 5. To learn about vocations	4. Make ink eradicator 5. Show how stains can be removed 6. Illustrate how CO_2 is necessary in our everyday life
3. Methods for removing stains from various materials Danger of cleaning fluids	6. Other objectives suggested by the class	7. Teach demonstration of uniting H_2 & O_2 8. Experiment showing amount of O_2 in the air
4. The laboratory New products discovered in the laboratory		9. Experiment showing neutralization *Other activities developed by the class*
5. Other content and problems suggested by the class		*Textbook study and use of reference materials* *Teaching films and exhibits* *Evaluation:* (See p. 90.) *Direct teaching where needed*

CLASS COMMITTEE WORKS ON PUMPS

Unit IX—A Life Problem Unit

HOW CAN WE FORCE WATER TO SERVE OUR NEEDS?

Overview by teacher and planning with pupils

1. *Aims*
   a. To provide the pupil with an understanding of the importance of water to his own life and man's activities
   b. To appreciate the importance of an ample supply of water not only for drinking purposes but for industry
   c. To understand that water can be used to develop an enormous amount of energy
   d. To understand that the sea is an untapped source of wealth

2. *Preview*
   a. From what source is our local water supply obtained?
   b. How can I purify water?
   c. Why does a steam iron need distilled water?
   d. How does a pump lift water?
   e. Why does hot water rise to the top of the boiler?
   f. What becomes of the rain which falls on the earth?

g. Why does a battleship float?
h. Why does a pond freeze from the top?
i. How does a pressure cooker work?
j. Why is it difficult to dive deep?

3. *Problem Situation*

Content	*Experiences*
a. Methods of purifying water	
(1) How can a city have a safe and sufficient water supply?	a. Visit the water supply system or report on the source
	b. Discuss New York water supply problem and rain makers
	c. Experiments on filtration, gravity supply, settling, effect of chlorine on paramecia
(2) Distillation of water	a. Needs of distilled water: batteries, medicine, steam irons
	b. Experiments on distillation and crystallization
	c. Test rain water
(3) Other methods	a. Report on aeration and bacteria (Saratoga swimming pool)
	b. Experiment on how sea water can be made into drinking water (Silver compounds)
(4) Hard water	a. Experiments in soap making, ways water can be softened, boiler scale
	b. Reports on soap products and uses
b. Water cycle	
(1) Evaporation	a. Experiments on humidity and its effect on drying, wet and dry thermometers, alcohol
(2) Condensation	a. Study weather reports and types of precipitation
(3) Underground water system	a. Report on underground rock formations and the effect on the water table
	b. Experiment on springs (water seeks its own level); show that backseeping of water forms swamps
	c. Report on water caverns
(4) Forest as a regulator of the water cycle	a. Report on water erosion and forests
	b. Visit erosion areas and reclamation projects
c. Sewage disposal methods	
Septic tank	a. Report on or visit a disposal plant
Cesspool	b. Report on the antipollution bill of 1945 (Act 177, Pennsylvania General Assembly)
Municipal disposal plants	c. Discuss location of a well and sewage drainage
River disposal	

Content	*Experiences*
d. Principles of water	
(1) Boiling and freezing	a. Experiment on freezing and boiling temperatures on F. and C. thermometers: show the expansion of water on freezing
(2) Pressure	a. Experiment on pressure increase with depth (Cartesian diver); show pressure same at any one point. Hydraulic press b. Report on dam construction
(3) Buoyancy	a. Experiment: Archimedes' principle
(4) Water as a source of energy	a. Report on hydroelectric plants
e. Sea is an untapped source of mineral wealth	a. Report on the Dow project b. Chart of minerals found in the sea
f. Water devices (1) Siphons (2) Pumps (3) Hydrometers	a. Show how to siphon an aquarium; read a hydrometer b. Report on how a force and lift pump works

4. *Additional Suggestions*

How the Navy refloats a ship
Study of hydroelectricity
How can a submarine travel under water?
Test soap products
Plan plumbing project
Project on the control of water erosion
Report on how the age of the earth is determined by estimating the amount of salt in the ocean
Report on vacation dangers due to impure water
Report on steam as a source of power

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6. *Evaluation* (See p. 90)

A FIELD TRIP

Unit X—A Journey

OUR CLASS VISITS THE FILTRATION PLANT

Situation:

An eighth grade class in general science was studying the unit on water. Within the unit we discussed the necessity of a good water supply. Our school water supply was investigated next. The questions of how our homes were supplied with water and at what approximate cost were next probed. Other questions followed as: "How do nearby cities secure their water supply?" "Is this supply always adequate?" An election was held and a student was elected to contact the local or nearby filtration plant and make arrangements for the class to visit the plant. Permission was secured from the school office and a bus was assigned us for the trip. None of the students had ever made this trip before.

Procedure:

The teacher asked: How shall we prepare for this trip? What monitors are needed? What questions shall we have answerd in order to make our trip worth while? Each student wrote up a list of questions that he hoped would be answered before he returned. Papers were collected. A student read off the questions. The good ones were written on the board, the poor ones eliminated. We entered the filtration plant

armed mentally with the following questions: How far into the lake do the intake pipes extend? How large is the intake pipe? (Guesses ran from four inches to six feet.) Does the water have to remain in the sedimentation beds longer at some times than at others? Does the amount of chlorine added vary or does it remain the same? What is the final test? Is anything added to quicken settling? How much water does the city use daily? How many gallons per person a day are allowed? What emergency methods are available? How are filter beds cleaned? How are odors removed? Of what are filter beds composed? What types of pumps are used? How is the cost of filtering the water taken care of? How many days a week do the men work?

Outcomes:

We spent two hours in the filtration plant and pumping station. This group had gained an insight into the importance of good water supply. They saw the dirty water enter the plant, smelled the strong vegetable odors, watched forms of life in it, looked at a drop of raw water and then at filtered water, observed immaculate laboratories, both chemical and bacteriological; saw test tubes and cultures of bacteria. Later the pupils were treated to a glass of water at the request of our guide. They saw the huge old steam pumps pump 900 gallons with each stroke and they observed the small, quick-acting electric pumps.

They talked to the men in the different departments and found them friendly and helpful.

Results:

The students learned the importance of a good water supply.

Some students received leadership training.

They developed a better understanding of the problems that face a community, appreciation for those who hold the health of others in their hands, a true meaning of conservation as it applies to each good citizen.

A "thank you" letter was sent to our guide.

Unit XI

HUMANE EDUCATION

Orientation by teacher and planning with pupils

Suggested activities: Pupil investigations and reports

A Study of Organizations

The studies under this topic should be considered for both rural and urban schools. Part of these assignments may be chosen for composition and theme work. They may also be coordinated with biology, civics, nature study, and out-of-door projects. The creature world and the out-of-doors become the laboratory for first-hand observation.

a. Note the scope of local organizations, their aims, and purposes.
b. A representative of an organization may appear before the group, or a student may be assigned to seek interviews and make reports. If the organization has

equipment, activities, or field projects, individuals or groups may be assigned to report on firsthand observations.

c. Check your community for the following:

Izaak Walton League
Audubon Societies
Sportsmen's organizations
The zoo or specialists on zoology
Bird sanctuaries
Wildlife reserves
Naturalists
Fur traders
Trapping industry
Government regulations on the seal industry
Wildlife fully protected by law
Predatory creatures covered by bounty

2. Shelter (mostly urban)

Projects for the conservation of birds and wildlife
Kennels for care, boarding or housing stray, lost or other animals
Visits to animal shelters or humane societies
Visits to veterinary hospitals

3. Handling Small Animals (urban and rural)

Safety precautions for the animal
Safety precautions for the handler
Classroom demonstration lesson by veterinarian
Methods of catching stray animals
Equipment for handling small animals
Precautions for handling diseased animals

4. Transportation (urban and rural)

Study express company regulations and shipment of small animals and poultry
Railroad car shipment
Truck shipment
Driving precautions for trucks
Loading and unloading precautions
Heavy losses by damaged carcasses or death
Livestock Loss Prevention Association (see slaughter-house management)

5. Cruelty in Motion Pictures (urban and rural)—English composition—Confer with producers—Write The Humane Association, Albany, N. Y.

Trick photography
Humane regulations in motion picture production
Study objections to portrayal of cruelty on the screen, real or apparent
Observe care of livestock in the motion picture field
  a. Compare these animals with like creatures in other fields
  b. Discuss pros and cons on humanities involved

6. Fur Farms vs. Native Furs (for rural field study—for urban library study)

Foxes, mink, chinchilla, etc.
Domesticating wild animals—wise or unwise—kind or unkind

7. Farm Animal Confinement (rural)—Contact Farm Bureau

Poultry kept in batteries
Forced feeding—ducks, etc.
Cattle confined in modern barns
  Advantages and disadvantages

8. Relation of Animal and Plant—Humanity in the balance—The field is your laboratory
   - Arbor Day and tie-in with animal assets
   - Insect enemies and their control
   - Birds, snakes, rabbits, skunks, toads, etc., as related to plant protection
9. Earth Worm Farming—a marvel in nature study— (rural) —See Pennsylvania State College Bulletin
   - Restoration of soil
   - Effect on crops
   - Production and marketing of earth worms and castings
10. Pests (rural principally)
    - Creatures that should be eradicated
    - Creatures that should be reduced in numbers only
    - Benefits that have been derived or attained from past life

C. *Pupil reports and exhibits*

D. *Evaluation*

GRADE NINE

Scope

One of the major concerns of the ninth grade student is that of adolescence. He is making a personal and social adjustment that will make him a definite personality. With such a problem in mind it will be wise for the science course to include units of diet, selection and care of clothing, the maintenance of good health, together with a general survey of physics, chemistry, and biology.

If the student can be made aware that science meets the needs of youth as well as those of adults, then he will develop a sound, workable scientific attitude.

Sequence

Unit I: How Can We Control and Use the Microscopic World?
Unit II: How Can I Keep My Body in Good Health?
Unit III: How Should I Select and Care for My Clothing?
Unit IV: What Should I Know About Growing Up?
Unit V: Machines We Use Today and Machines of Tomorrow
Unit VI: What Activities Depend on the Sun and the Universe?
Unit VII: Why Must the World Have Light?
Unit VIII: How Do Electrons Work?
Unit IX: Life Problem Unit: What Foods Should I Eat and How Does My Body Use Them?
Unit X: Report of School Trip: Our Class Visits a Planetarium

Evaluation

For the evaluative procedures which should be used at the termination of each unit, the user of this bulletin is referred to Section 1 of Chapter II, "Teaching Science by Units," and to Chapter IV, "Evaluation." Co-operative teacher-pupil evaluation and direct drill techniques, where needed, should be characteristics of all good evaluation. Sample pupil check lists are included for this purpose for Units VI and VII. Others may readily be constructed.

Unit I

HOW CAN WE CONTROL AND USE THE MICROSCOPIC WORLD?

1. *Overview: (by teacher)*
2. *Teacher-pupil planning:* (group discussion)
   a. What do we know now? (list on blackboard)
   b. What do we need to find out? (list on blackboard)
   c. What work plan shall we use? (list committees for reports)

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Molds and yeast: a. Nature of molds b. On what and where do molds grow? c. Uses for molds d. Our debt to yeast plants: (1) Alcohol and carbon dioxide uses (2) Fermentation (3) How do yeast plants grow?	1. Appreciation of the problem of food preservation	1. Use the microscopes to study yeasts, molds, protozoa
2. Using bacteria and fighting them: a. Description and habitats b. Uses for bacteria, as vinegar, purification, tanning, flavoring c. Food poisoning and disease: (1) Ways of preventing disease (2) Helping the body fight disease (3) Ways of preventing food poisoning (4) Ways diseases are spread (5) Modern medicine	2. To realize how the methods of refrigeration and other preservation methods have changed the diet of America	2. Collect other species of fungi
3. Protozoa—the one-celled animals	3. To realize the value of bacteria	3. Report on the various modern drugs
4. Other content and problems suggested by the class	4. To realize that it is every person's duty to obey health rules	4. Controlled experiment showing sterilization
	5. To appreciate the advancement of modern medicine	5. Report on methods of insect control (DDT)
	6. To realize the part microorganisms play in everyday life	6. History of malaria and yellow fever epidemics
	7. Other objectives developed by the class	7. Grow protozoa with hay infusion
		8. Chart showing uses for alcohol
		9. Study and report on various methods of preserving food
		Other activities suggested by the class
		Textbook and reference study
		Evaluation: a. See page 106 of this Section and Chapter IV b. Self-appraisal c. Achievement Test
		Direct teaching where needed

UNIT II

HOW CAN I KEEP MY BODY IN GOOD HEALTH?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
1. Nervous system: a. Functions b. Is a nerve electric? e. Involuntary system d. Voluntary system e. Brain f. Nervous disorders and corrections 2. My eyes: a. Parts and their function b. Focusing with and without glasses c. Color detection d. Night blindness e. Eye defects and corrections 3. My ears: a. Parts and functions b. Defects and corrections 4. Respiratory system: a. How do we breathe? b. Diseases and cures 5. Circulatory system: a. Blood and its function b. How blood circulates c. Heart d. Disease and cures e. Corpuscles 6. Digestion: Trace the classes of food through the alimentary canal 7. Other content and problems suggested by the class	1. To understand the parts of the body 2. To learn the requirements for the practice of medicine and nursing 3. To recognize disease or defects and the possible corrections 4. To study adolescent development 5. Other objectives developed by the class	*By class or committees* 1. Demonstrate reflexes 2. Check reaction time 3. Check the size of the pupil of the eye in direct light 4. Check hearing 5. Report on "dog" whistles used in movies 6. Hearing aids 7. Report on or visit a hospital for blood tests 8. Check the heartbeat and respiration 9. Chart on digestion 10. Food tests *Other activities suggested by the class* *Textbook and reference study* *Evaluation:* (See p. 106.) *Direct teaching where needed*

Unit III

HOW SHOULD I SELECT AND CARE FOR MY CLOTHING?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Fabric adulterated	1. To acquire a better understanding of the clothing problems	1. Collect many types of cloth
2. Fibers under a microscope	2. To learn how to buy scientifically	2. Distinguish fibers under the microscope
3. Heat transfer and the type of fabric	3. To understand terminology on labels	3. Test soap with borax, etc.
4. How does soap remove dirt?	4. To learn about selling as a vocation	4. Show how spots can be removed
5. Proper steps in laundering	5. To know the correct steps in laundering	5. Report on methods of moth-proofing materials
6. Removing stains and spots	6. To study color combinations	6. Show correct method of dyeing
7. Fabric colors—methods of dyeing	7. Other objectives developed by the class	7. Report on modern washing machines
8. Protection of materials from moths		8. Visit a clothing store. Hear talk by manager
9. Weatherproofing		*Other activities suggested by the class*
10. New fabrics		*Textbook and reference study*
11. Reading of labels		*Evaluation:* (See p. 106.)
12. Other content and problems suggested by the class		*Direct teaching where needed*

UNIT IV

WHAT SHOULD I KNOW ABOUT GROWING UP?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
1. Are you normal? a. Physical: (1) Exercise (2) How to lose weight or gain weight without danger (3) Adolescent acne (4) Posture (5) Good grooming (6) Have you developed a sport as a recreational outlet? b. Glands: (1) Endocrine (2) Duct glands c. Classes of foods and the nutritional requirements d. Vitamins and a balanced diet e. Care of the teeth f. Habits are hard to get rid of 2. Other content and problems suggested by the class	1. To aid the adolescent in gaining self-confidence 2. To learn how to make friends 3. To recognize the necessity of a balanced diet 4. To learn how to make dates 5. To realize that glands are the regulators of body development 6. To find out what an I.Q. is 7. Other objectives developed by the class	*By class or committees* 1. Personal inventory 2. Planning of menu for gaining or for losing weight 3. Discussion of soaps 4. Posture charts 5. Charts on glands 6. Write a menu for balanced diet for an average family for a week—check food costs to keep within the budget *Other activities suggested by the class* *Textbook and reference study* *Evaluation:* (See p. 106.) *Direct teaching where needed*

UNIT V

MACHINES WE USE TODAY AND MACHINES OF TOMORROW

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Simplest machines: a. Levers b. Pulleys c. Inclined planes d. Wheels and axles	1. To be able to recognize the simple which makes the complex	1. Experiments with levers, friction, inertia
2. Friction—a friend and an enemy	2. To use machines efficiently	2. Use erector set to show the advantages of gears
3. Inertia	3. To understand that energy can be transformed	3. Booklet on jet planes and speed faster than sound
4. What is work?	4. To realize the rapid advancement of machines	4. Study a door check
5. Complex machines are part of modern transportation: a. Steam engine b. Gasoline engine c. Diesel engine d. Jet engine e. Hydraulic machines f. Atomic energy harnessed	5. To study the operation and care of an automobile engine	5. Visit a local garage or the school auto mechanics shop when a motor is being overhauled
6. Other content and problems suggested by the class	6. Other objectives developed by the class	6. Report on diesel engines
		7. Look up reference material on rockets
		Other activities suggested by the class
		Textbook and reference study
		Evaluation: (See p. 106.)
		Direct teaching where needed

UNIT VI

WHAT ACTIVITIES DEPEND ON THE SUN AND THE UNIVERSE?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. The sun is the center of our solar system: a. Planets, moon, stars b. Gravitation	1. To appreciate the dependence of the earth on the sun	1. Report on planetariums 2. Report on solar heating 3. Balance an aquarium
2. The earth taps the sun for its heat, light, and power: a. Fuels are stored up sunshine b. Radiometer c. Solar heating	2. To realize that all natural sources can be traced back to the sun's energy 3. To learn to recognize the stars 4. To acquire a better understanding of the need for conservation of plant and animal life	4. Check plant growth—sunlight by controlled experiments 5. Collection of coal 6. Make a chart showing the planets
3. Our food, shelter, clothing are dependent on the sun: a. Balance of plant and animal life b. Photosynthesis c. Matter cycle and energy cycle	5. Other objectives developed by the class	7. Radiometer demonstration 8. Report on cosmic rays *Other activities suggested by the class*
4. The sun regulates the water cycle, weather, seasons, fresh air		*Textbook and reference study* *Evaluation:* (See p. 106.)
5. The sun provides important vitamin D needed for life		*Direct teaching where needed*
6. The sun gives the earth molecular and chemical energy		
7. Conservation of our plant and animal life		
8. Other content and problems suggested by the class		

Student Self-Appraisal Check List for Unit VI

WHAT ACTIVITIES DEPEND ON THE SUN AND THE UNIVERSE?

1. *Useful Knowledge*

	Yes	*D.*	*No*
a. Can you explain how we know what is in the sun?			
b. Can you demonstrate how a telescope works?			
c. Do you know what keeps the sun, earth, moon, and planets in place?			
d. Can you discuss some superstitions about the moon?			
e. Can you explain what causes the change of seasons?			
f. Do you know what causes the moon's phases?			
g. Can you explain three ways by which an airplane navigator can find out where he is?			
h. Can you diagram and recognize six constellations?			
i. Do you know how many stars can be seen with the naked eye? With a powerful telescope?			
j. Do you understand what a knowledge of the solar system has to do with you personally?			

2. *Vocabulary*

Can you explain and use the following words or terms?

	Yes	*D.*	*No*		*Yes*	*D.*	*No*
a. astronomy				f. gravity			
b. astrology				g. inertia			
c. constellation				h. orbit			
d. eclipse				i. spectroscope			
e. equinox				j. solstice			

3. *Principles and Laws*

Can you state four scientific principles or laws which explain any of the following?

hot weather in summer, gravity, change of seasons, day and night, tides, time belts, short days and long days

1. ______
2. ______
3. ______
4. ______

4. *Daily Activities and Phenomena*

Can you list four daily activities which illustrate the following?

gravity, inertia, momentum, pendulum, rotation, revolution

1. ______
2. ______
3. ______
4. ______

5. *Demonstrations*

Can you prove by demonstrations that:

	Yes	*D.*	*No*
a. Elements give off light?			
b. The color emitted by a hot element depends on what it is?			
c. Change of seasons is caused by the earth's movement?			
d. The time of a pendulum depends upon the cord's length?			
e. The moon has (or has not) an effect on seeds or on shingles?			

6. What else did you learn in this unit?

What help did you give to the work of the class?

UNIT VII

WHY MUST THE WORLD HAVE LIGHT?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Sun is the source of heat and light rays Ways of producing light	1. To know the value of all methods of lighting	1. Lighting system used in modern buildings
2. Casting a shadow Eclipses	2. To understand that without light man could not survive	2. Make a periscope
3. Reflection and the use of mirrors	3. To learn methods of preventing eye-strain	3. Develop negatives and print and develop pictures
4. Methods of lighting our homes	4. To learn to use optical instruments correctly	4. Report on night blindness
5. Refraction—bending of the light rays	5. To learn about an electrician's job	5. Test Polaroid glasses
6. Lenses and eye defects a. Eye is a camera b. Correction of eye defects c. Persistence of vision	6. Other objectives developed by the class	6. Report on animated motion pictures
7. Camera and photography a. Parts of a camera b. Developing of a negative and a positive		7. Demonstrate lunar and solar eclipses
8. What is color? a. Spectrum b. Why the rose is red c. Color blindness d. Ultraviolet and infrared rays		8. Plan a new lighting system for the home or school
9. The world is dependent on light for survival		9. Use of the microscope
10. Other content and problems suggested by the class		10. Talk by an electrician
		Other activities suggested by the class
		Textbook and reference study
		Evaluation: (See p. 106.)
		Direct teaching where needed

STUDENT SELF-APPRAISAL CHECK LIST FOR UNIT VII

WHY MUST THE WORLD HAVE LIGHT?

1. *Useful Knowledge*

	Yes	D.	No
a. Do you know where light comes from and how it travels?			
b. Can you explain how a mirror enables you to see yourself? ...			
c. Can you explain how the shape of a mirror affects what is seen in it?			
d. Do you understand how bifocal glasses work?			
e. Can you name the parts of a telescope, microscope, and binoculars?			
f. Can you name the parts and explain the operation of a camera?			
g. Can you name the parts and explain the operation of the human eye?			
h. Do you know what factors to consider in choosing paint?			
i. Do you know what contributions to science were made by Roemer, Michelson, Newton, and Planck?			
j. Can you explain the cause of various colors?			

2. *Vocabulary*

	Yes	D.	No
a. candle power .			
b. color blindness			
c. complementary colors			
d. diffusion			
e. focal length . .			

	Yes	D.	No
f. infrared			
g. lenses			
h. lumens			
i. quanta			

3. *Principles and Laws*

Can you name six principles or laws which explain any of the following?

Eyestrain, sightseeing, stargazing, searchlights, color, rainbow, opera glasses, burning lens, projectors, motion pictures

1. ____________________ 4. ____________________
2. ____________________ 5. ____________________
3. ____________________ 6. ____________________

4. *Daily Activities and Phenomena*

Can you name six activities or phenomena which illustrate any of the following?

Light reflection, light speed, image reflection, principles of lenses, color photography, pigment

1. ____________________ 4. ____________________
2. ____________________ 5. ____________________
3. ____________________ 6. ____________________

5. *Can you demonstrate*

	Yes	D.	No
a. How a photometer works?			
b. A desk lamp that produces the best light?			
c. Colors that are pleasing for interior decoration?			
d. How a telescope works?			

6. *What else did you learn in this unit?*

7. What help did you give to the work of your class?

UNIT VIII

HOW DO ELECTRONS WORK?

Overview by teacher and planning with pupils

Content	*Objectives*	*Learning Experiences and Reports*
		By class or committees
1. Properties of magnetism and electricity: a. Electricity can be produced by friction, chemical action, and magnetic induction b. Why do homes have parallel wiring? c. What is the value of series wiring? d. What are some uses for magnets? e. Electric motor and generator f. Electric heat devices g. How to connect electrical appliances h. Measuring electricity; Ohm's Law i. Telephone changes sound to electrical vibrations j. Radio is an electrical vibration k. Telegraph uses code l. Photoelectric cells 2. Other content and problems suggested by the class	1. To recognize the dangers in the abuse of appliances 2. To understand the rapid development of electrical devices and the opportunity for still greater achievements 3. To recognize that modern communication has made our world small 4. To understand how audio and video transmission is possible 5. To study jobs in electronics 6. Other objectives developed by the class	1. Experiments: Electroplating, static electricity, magnets, series and parallel wiring, radio, telegraph, motor, bell 2. Read electric meter 3. Talk by a radio man 4. Biography of Franklin, Morse, Bell, Marconi, Steinmetz 5. Visit a radio station *Other activities suggested by the class* *Textbook and reference study* *Evaluation:* (See p. 106.) *Direct teaching where needed*

Unit IX—A Life Problem Unit

WHAT FOODS SHOULD I EAT AND HOW DOES MY BODY USE THEM?

1. Preliminary teacher planning:

a. The class has studied a unit on air and water. Since our bodies also need food to survive, the teacher thinks food would be a good area to use next.

b. The unit is presented by asking the class what the body needs besides air and water.

c. The teacher asks what things the class think they should know about foods. These are written on the blackboard.

2. Orientation: (by class)

You have heard your bodies compared to engines, and you know foods are the fuels that make the human engine go. If you were using an automobile you would always try to buy the best oil and gas you could if you wanted to make mileage. In heating our homes our fathers buy the best fuel they can for the money. Stoking the human machine is even more important. Being ignorant about the kinds of foods that are best for us is like going to a coal dealer and buying coal mixed with slate. We just can't afford to be ignorant about foods and their uses.

The films "Meat and Romance," "The Balanced Way," and "Citrus in Nutrition" provided a great deal of motivation.

The pupils decided to learn:

a. Classes of foods and uses
b. Tests for foods
c. Amount of calories needed
d. How to balance a diet
e. Effects of improper diet
f. Effects of overeating.
g. How to buy foods

3. Learning Period:

a. Committees were set up for each of the above areas.
b. All pupils decided to secure as much additional material as they could.
c. Prices of certain foods were obtained from local stores.

4. Culminating Activity:

a. Group reports were given.
b. Many charts were made.
c. Dramatizations of ordering correct and incorrect meals were given.
d. An exhibit of foods under the Basic Seven was arranged.

5. Evaluation:

a. The class decided that stores could arrange foods by groups and help the buyer in selecting an adequate diet.
b. The group learned a great deal in the buying and proper preparation of foods.

The Teacher's Plan

1. Desired Outcomes:

a. *Knowledge and understanding*

(1) Green plants serve as the source of all foods
(2) Green plants make their own food

(3) Nongreen plants and animals are dependent on green plants
(4) Food is carried to all parts of the body by blood
(5) The discharge of waste material is essential

b. *Habits and skills in*
(1) Observing the growth of plants and animals
(2) Performing experiments and demonstrations
(3) Selecting proper foods
(4) Preparing a balanced diet

c. *Attitudes and appreciations*
(1) Value of green plants
(2) Importance of proper foods
(3) Working of our body organs

2. Overview:

The green plant is the basic food supply of the world. In this unit the pupils should learn how the many kinds of foods that we eat come directly or indirectly from green plants; also that the proper selection of food and its digestion are important factors in our health.

3. Outline of Content:

a. *Basic sources of food:*
(1) Sources
(a) Green plants
(b) Animals

(2) How green plants make food:
(a) Sunlight
(b) Chlorophyll
(c) Water
(d) Carbon dioxide (CO_2)
(e) Work of the roots
(f) Work of the trunk
(g) Work of the buds

(3) How foods are used by animals
(a) One-celled animals
(b) Complex animals

(4) How nongreen plants and animals get food and energy
(a) Nongreen plants—bacteria, bread mold, others
(b) Animals—carnivorous, herbivorous, omnivorous
(c) Parasites and saprophytes

b. *How food is supplied to the parts of the body:*
(1) Structure and organs of the human digestive system

Structure:	Organs:	Glands in the digestive system:
Cells	Mouth	Salivary
Tissues	Pharynx	Gastric
Organs	Esophagus	Liver
Systems	Stomach	Pancreas
	Small intestine	Intestinal
	Large intestine	

(2) Digestion
    Definition
    Diffusion
    Nutrient substance in food

(3) How we digest and absorb food
    (a) Work of enzymes
    (b) Saliva
    (c) Gastric juice
    (d) Bile
    (e) Pancreatic juice
    (f) Intestinal juice
    (g) Process in small intestine
    (h) Absorption of food

(4) How food and oxygen are carried to the cells
    (a) Circulatory system
    (b) Blood—
        Plasma
        Red corpuscles
        Lymph

c. *How cells use food*
   (1) Animal cells
       (a) For energy
       (b) For growth
       (c) For repair
   (2) How wastes are discharged
       (a) Kidneys
       (b) Skin
       (c) Liver
       (d) Large intestine

d. *Food and health:*
   (1) Balanced diet
   (2) Nutrients
   (3) Proper number of calories
   (4) Value and source of vitamins
   (5) Microorganism
       (a) Beneficial
       (b) Harmful

4. Suggested activities:

a. Make test for starch in food.
b. Make test for sugar in food.
c. Make chart to compare amount of proteins, carbohydrates, and fats in various foods.
d. Demonstrate: Green plants need light.
e. Make drawing of plants and label parts.
f. Examine cross section of woody stem under microscope and note cells.
g. Show how liquids rise in stem.
h. Observe cell division.
i. Observe single cell under microscope.
j. Discuss functions and parts of tree.
k. Prepare bread to make mold.
l. Name some carnivorous animals, herbivorous, and omnivorous.
m. Name some parasites and saprophytes.

n. Name some foods that are roots, stems, and leaves.

o. Study diagram of human digestive system.

p. Demonstration: diffusion.

q. Observe effect of saliva on starch.

r. Observe blood circulation in tail of fish.

s. Study structure of beef heart.

t. Observe amoeba under microscope.

u. Study diagram of human respiratory system.

v. Demonstrate effect of exercise on circulation and respiration.

w. Calculate a balanced diet.

x. Survey pupil food habits. Check table of a week's diary with what should be included.

y. Discuss food purchases, how to get the best for the money. Talk by home economics teacher.

z. Study vocations and pay in food industries and medicine. Pupils prepare a vocational chart showing: (1) jobs or professions, (2) average yearly income, (3) training required.

5. Evaluation

a. *Prepare check lists and questionnaires to appraise the development of the following behaviors:*

(1) Ability to choose a well-balanced diet

(2) Good food habits

(3) A liking for a variety of foods

(4) A feeling of responsibility in helping influence good food habits in others

(5) Knowledge of the functions of the nutrients for body growth and maintenance

(6) Appreciation of the physical evidences of good nutrition and a willingness to work to achieve them

(7) Appreciation of the possible danger to dental health resulting from poor food habits

(8) An understanding that food customs in various parts of this country and in other countries vary and that it is possible to achieve a balanced diet by choosing wisely among foods that are unfamiliar to us

(9) An understanding that food fads, fallacies, and superstitions are not based on scientific research

(10) An understanding that the information we have concerning nutrition is a result of research and that future research will teach us many additional things about food and its use

(11) An understanding of the importance of careful food handling

(12) An understanding that the way food is processed and prepared affects its nutritional value

(13) Some knowledge of acceptable methods of food preparation and food preservation

(14) Desire to get more food value for the money spent on "snacks"

(15) Appreciation of the possible contribution of the school lunch program toward good nutrition

(16) Ability to find authentic information concerning nutrition in current books and periodicals

b. *Check by functional unit test, questionnaire, and observation pupil understandings of the facts discussed in the following presentation and the chart on page 122.*

The Contributions of a Type A Lunch Toward the Total Daily Nutrition Needs of School Children

Children of all ages need three good meals a day. Only through foods of high quality can children obtain their total nutrition needs for energy, for protein, for the minerals, calcium and iron, and for the vitamins A, B, C, and G.

Each column on the chart (page 122) represents one of these nutrition needs measured in shares. Every day children of the primary age group need enough food to reach the lowest line of stars in each column. The elementary and junior high school pupils need more, enough to reach the goals represented by the middle row of stars. A senior high school boy is always hungry because he needs so much more than the others. His goals and daily needs are indicated by the top row of stars.

The school lunch program operates for the benefit of all groups but furnishes only one of the needed three daily meals. The school meal should supply a third of a child's nutrition needs for the entire day. Breakfast and dinner are the responsibility of the home.

The blocked portion at the bottom of each column shows what a typical Type *A* lunch provides and just how far it goes toward meeting the total daily nutrition needs of our school children in the different grade levels. (Grouped for practical use.) What a typical *A* lunch contributes toward these is shown by the blocks in the area at the bottom of the chart.

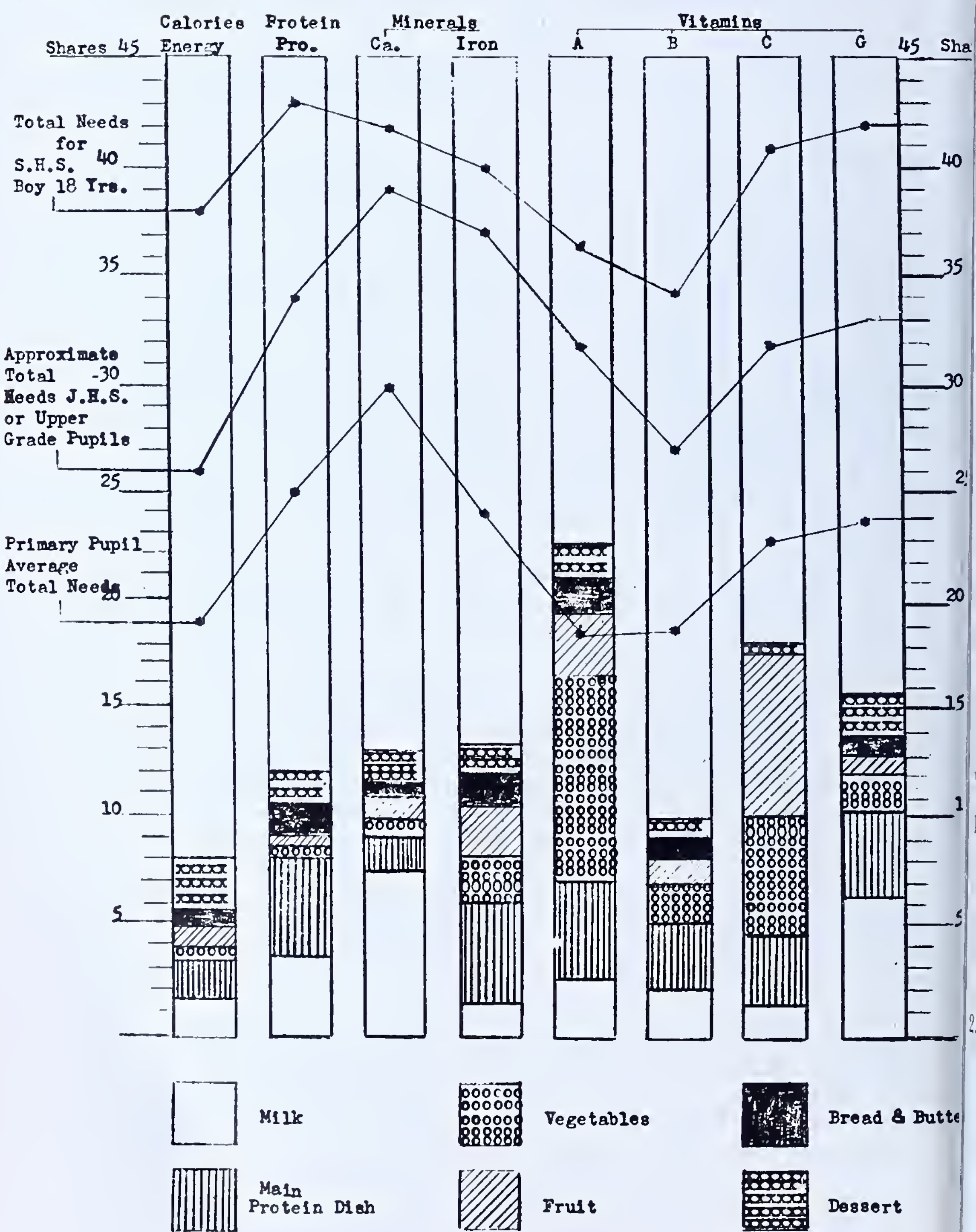
The bottom unmarked block in each column shows just what a bottle of milk contributes. Reading up, the second block shows what a portion of a main dish like stew, meat patties, cheese fondue, fish, eggs or beans, on an average, supplies. The third block above that represents an average serving of vegetables; the fourth, an averaged serving of fruit; the fifth, a serving of bread such as whole wheat, Boston brown, cornbread, or rolls when averaged together and served with butter or fortified margarine; sixth and top, the needed contributions of a simple dessert.

The chart reveals at a glance just how far the school meal goes toward meeting the approximate total nutrition needs of children in the different grade levels; what adjustments are needed if it is to meet a third of their total needs; and how far short lunches fall in meeting our topmost responsibility of the school lunch program to the high school boy at the peak of his growth needs.

Desserts, if well planned, can be inexpensive. Dried eggs, dry skim milk solids, dried fruits and honey, all free USDA* foods, can be made into excellent desserts of a great variety. Only foods that make a contribution to the total needs of growing children should be offered in the school lunchroom, but unless the school attempts to meet the energy needs, children will fall into bad food habits. A recent study revealed that 42 per cent of the children surveyed spent ten cents or more daily on snacks. Why not offer them a nutritious dessert in school to replace candy and beverages furnishing calories only?

The total day's needs must not overlook a good breakfast and a suitable dinner at night, but these are the responsibility of the home, and these two meals added to the school lunch should bring the total food values up to the stars or daily goals.

* United States Department of Agriculture.



CONTRIBUTION OF A TYPE A LUNCH TOWARD THE DAILY NUTRITION NEEDS OF SCHOOL CHILDREN

Unit X—Report of a School Trip

OUR CLASS VISITS A PLANETARIUM

Situation

The ninth grade science class had begun to study a unit on astronomy. One of the pupils asked, "Could we go to visit the Buhl Planetarium in Pittsburgh?"

A committee was appointed to investigate the transportation problem. In a few days the committee reported the cost of the trip as obtained from three companies. The group decided upon a company and asked the teacher to hire one bus. Each pupil paid his share of the transportation.

The class was divided into committees which explored different phases of the unit. Several moving pictures were shown. The class decided to visit the Carnegie Museum also.

All plans worked out very well. We visited Carnegie Museum in the morning, then spent the afternoon at the Buhl Planetarium, and the evening at the Allegheny Observatory. Here we saw firsthand three telescopes. Their operation was explained. In addition, we heard an excellent illustrated lecture in the science hall of the observatory.

Outcomes

The group gained experience in planning and carrying out an excursion. The unit was made meaningful, interesting, and the pupils learned much as tests showed. An extra interest in the study was obtained by the excursion. The following functional information and principles were learned:

1. *The sun rules our daily lives:*
   - a. Effects of sun's energy
     - (1) Direct uses by man
     - (2) Direct uses by plants
     - (3) Water cycle
     - (4) Fuels
     - (5) Conservation of fuels
   - b. Nature and composition of the sun
     - (1) Nature of sun
     - (2) Sun spots
     - (3) Composition of sun
2. *The remarkable feature of the universe is its orderliness:*
   - a. Nature of solar system
     - (1) Members of solar system
     - (2) Motions and forces in solar system
     - (3) Origin of solar system
     - (4) Moon and its motions
   - b. Beyond the solar system
     - (1) Stars
     - (2) Constellations
     - (3) Galaxies
     - (4) Telescopes
   - c. Astronomy versus astrology
     - (1) Origin of each
     - (2) History of the development of each
     - (3) Present status of each
     - (4) Orderliness in the universe

3. *The motions of the earth produce orderly changes in our environment:*

   a. Effects of earth's motions
      (1) Day and night
      (2) Seasons
      (3) Changing appearance of sky

   b. Uses of earth's motions
      (1) Determining direction
      (2) Recording position
      (3) Reckoning time

SECTION 2

SCIENCE IN THE SENIOR HIGH SCHOOL

Trends in the enrollment and in the planning of science courses in both the junior and senior high schools emphasize the needs of the consumers of scientific knowledge. The number of pupils in the less formal science courses and the variety of courses offered have increased. Unification of some courses under the name "biology" is an established fact. Further unification in physical science is growing. In the more formal science courses, the great social objectives of secondary education are finding increasing expression.

The spiraling complexity of a scientific age, the hoodwinking of the public with pseudoscientific commercialism, superstitions, and unreasoned prejudices all urge emphasis in the science program toward social goals. However, there is a simultaneous demand for trained scientific leadership. This calls for the early specialization and concentration of science-talented youth.

Specialization and Socialization—Two Views

Socialization takes the form of a social development which is focused on the life and needs of all learners and an approach which takes advantage of opportunities and uses direct teaching for the practical application of more abstract generalized concepts. *Specialization* involves continued grade by grade experiences in science education. It includes increasing skill in the use of the mathematics and symbols which form part of the language of science. Both socialization and specialization, like all effective teaching, depend for attainment upon the education which is meaningful and functional to the learner himself.

Effective specialization at the secondary level is founded upon the information and understanding which are used. Thus the learner should be guided repeatedly into many real—not artificial—situations in which technical knowledge and skills are used in developing scientific behaviors through everyday concrete experiences.

Specialization is the outgrowth of the common learnings which are needed by all youth. Research indicates that adolescent problems and the lack of basic scientific knowledge for living persist, almost undiminished, throughout the secondary school years. Experience with the

immediate and concrete leads to technical generalizations, abstractions, and facility with the use of symbols. Where needed, direct teaching and drill follow experience with matter and problems which are familiar to the learner. This has always been the method of effective science teaching.

Problem-Solving Activities

The literature on science education and modern courses of study focus upon the attainment of functional information, understandings, attitudes, and behaviors. These are designed for the general education of all youth and for the pretechnical education of science-talented youth. These functional objectives lead beyond shallow verbalized memory. For accomplishment, they require classrooms that are learning laboratories. Learning activities are the only known antidote for verbalism. Problem-solving situations, which are characteristic of science education, provide an endless array of activities of this type.

In the biology, physics, chemistry, and physical science courses which are presented, functional problems are frequently suggested. These are designed to stimulate local planning of a similar type. Local planning should be both preplanning by the teacher himself and pupil-teacher planning. The latter reveals pupil concern and enhances the participation which only democratic processes develop.

Functional problems are derived from sequential subject matter requirements. They are based also upon the natural curiosity, compulsions, and concerns of youth. They should pose themselves in natural spontaneous situations rather than be presented entirely by the teacher or course-of-study committee in a formal or verbal manner.

Selection of Science Experiences

The rapid growth in the applications of scientific principles, comparable only to the Bikini mushroom itself, has tended to push the covers of science textbooks far apart. The attempt to cover a text becomes increasingly absurd. There must be selection in terms of the principles and understandings which youth needs in an atomic age. The functional values, upon which both education for living and pretechnical learning depend, become criteria and points of emphasis.

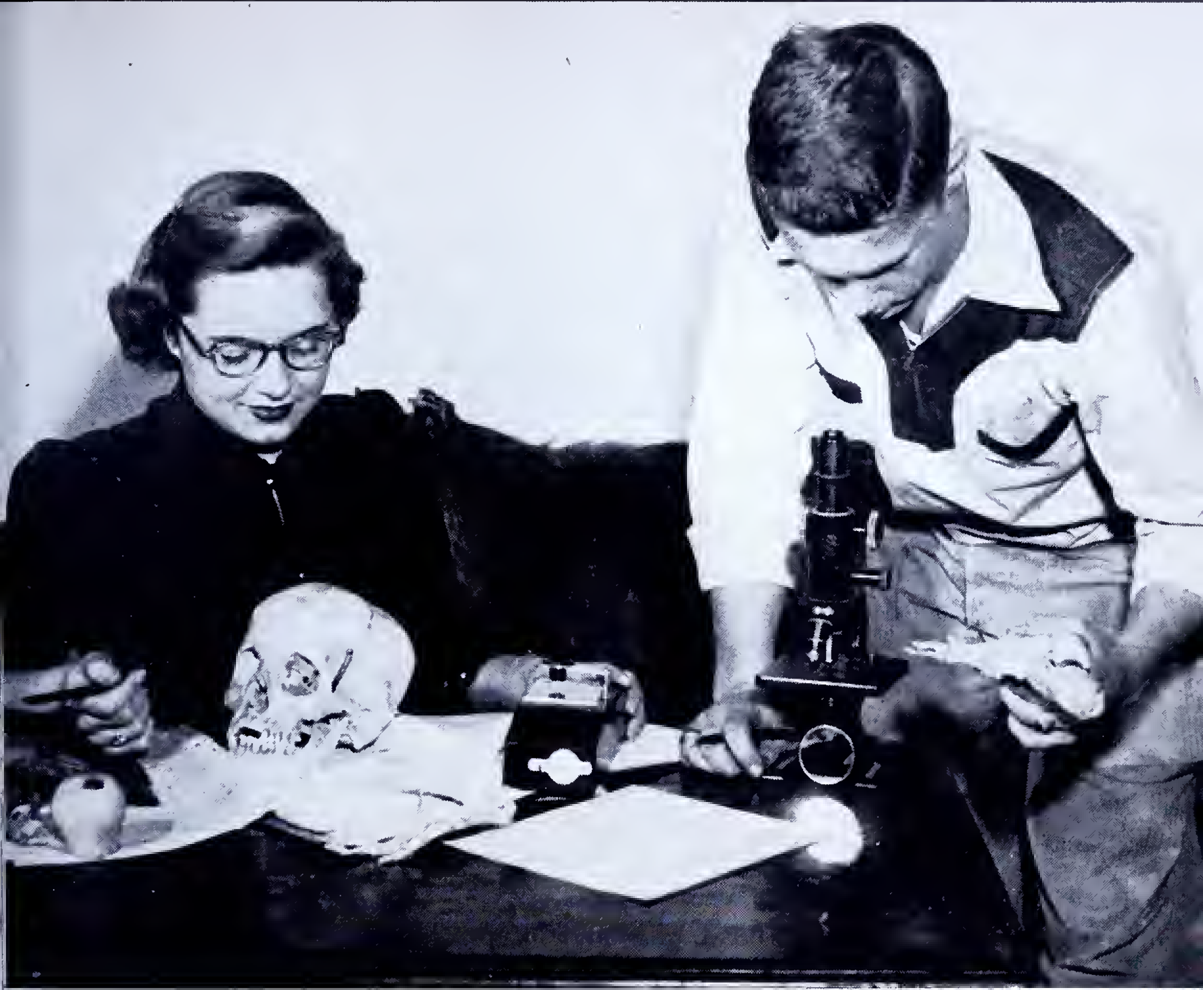
Functional learning and transfer require the student—under guidance—to make many applications of the basic principles of science. These are comparable in number to nearly all the everyday activities which come to mind. The wealth of available applications to the learner's own environment and experience provides a variety of illustrations for immediate use in meeting the diverse interests and needs of all youth.

These and other means provide procedures of a problem-solving, inductive type to keep science education out of the shallows into which cookbook methods may take it.

How to Use the Senior High School Courses of Study in Science

Facility with the courses of study in biology, chemistry, physics, and physical science will be increased if Chapter I, "Problems of Science Education," Chapter II, "Achieving Greater Goals in Science Education," and Chapter IV, "Evaluation," are frequently reviewed. The principles which are expressed have been developed: (1) from cooperation in this study by the nine district science committees, (2) from the discussions of the State Science Curriculum Committee, (3) from the literature and research on science education, and (4) from the *Evaluative Criteria* of the Middle States Association. The various courses of study and the units included in them are an expression of these principles. They are best understood and most easily used in their relationship to the whole of which they form a part.

Reports on the tryout and further development of the courses of study and suggested units will be greatly needed for the future revision of this bulletin. In addition, reports of the means used for the *comprehensive evaluation* of the units and the results, in terms of individual and group growth, will add greatly to the improvement of science education in the State. The district science chairmen will welcome such cooperation and materials.



FOCUS ON THE STUDY OF MAN

BIOLOGY

Scope

Man is a reactive organism, as are all living creatures. His ability to adjust himself successfully to the demands of an ever-changing world will be determined by the behaviors which are developed in him through an understanding and practice of behavior patterns common to all. Did the study of biology do no more than enable man to understand his own behavior, to enlarge his understanding of himself in relation to others, it would justify careful consideration.

Trends in biology teaching indicate that subject matter has become less technical and more practical, with increasing emphasis on functional values. Present-day biology teaching avoids the situation where pupils are able only to state a principle correctly. If they do not use it in ordinary life, they have not really learned it. Nowhere is the transition from lesson learning to learning by doing more apparent.

The study of biology (1) should demonstrate the order which inheres in creation and seeks to reduce the phenomena of nature to simple

laws, (2) should foster the idea that truth is immutable, although our concepts of it are subject to error, (3) should stress vocational and avocational ramifications that add to its value, (4) should develop greater tolerance from the realization that behavior is largely conditioned, that difference in color of skin and facial contours are superficial only and nature's product of selection and protection, and (5) should bring about a fuller enjoyment of the aesthetic values in life and more perfect adjustment of man to his changing environment.

Education is the immortal chain which provides a link with the past and continuity with the future. One of its functions is to perpetuate our great heritage of biological experience. Familiarity with some of the great literature of science, together with the knowledge of the experiences of those who have done so much to contribute to the present knowledge, demonstrates the place of science in the evaluation of human thought.

Direct participation in real scientific experience must be an integral part of biology education. Learning activities which involve the methods and techniques of science form the foundation for transforming natural curiosity into the habits of critical thinking.

No one learns unless he thinks; no one thinks unless he has a problem. The gathering of facts, in order to solve a problem, is well motivated. The pupil uses information and subject matter from many sources, from far more sources than are used in an assign-study-recite textbook procedure. The units which make up this course start with a problem and then seek subproblems, facts, principles, that are essential to the problem-solving. Thus habits of thinking are developed by thinking, not by repeating what others have said.

Sequence

To provide the learning experiences and behaviors which youth needs to achieve these goals, the following sequence is suggested:

UNIT I: How Do I Depend Upon My Physical Surroundings for Existence?
UNIT II: How Do Living Things Obtain Food?
UNIT III: How Do Living Things Assimilate Food?
UNIT IV: How Do Living Things Grow?
UNIT V: How Do Living Things Maintain Their Kind?
UNIT VI: How Are Living Things Classified?
UNIT VII: How Do Living Things React to Their Environment?
UNIT VIII: How Are Living Things Fitted to Their Environment?
UNIT IX: Why Must I Constantly Adjust Myself to My Environment?
UNIT X: What Are the Ways in Which I Can Use Living Things?
UNIT XI: How Can I Improve Living Things?
UNIT XII: Why Must I Control My Environment in Order to Assure Satisfactory Existence?
UNIT XIII: Life Problem Unit: How Will Biological-Medical Research Help Me to Live Longer?

UNIT XIV: Life Problem Unit: How Can We Raise Plants in the Absence of Soil?
UNIT XV: Life Problem Unit: How Can I Avoid Stimulants and Injurious Drugs?
UNIT XVI: Humane Education

Introducing Units

Pupil-teacher planning is a necessary phase of effective functional education. (See *Evaluative Criteria* of the Middle States Association, D-15.) In introducing the biology units, provisions should be made for this essential motivation. This is especially advisable in biology, for pupils already know a great deal about the problems. This may take the form of:

1. Overview by the teacher—Importance of the unit, etc.
2. Group discussion:
   a. What do we know now?
      (List on blackboard)
   b. What do we need to find out?
      (List on blackboard)
   c. What work plan shall we use?
      (List problems and committees on blackboard)

The unit outlines are suggestive and flexible. They should be extended to meet specific problems of pupils and the needs of local communities, rural or urban. Variation in topics, problems, and activities will be desirable as circumstances vary.

Evaluation

Data on the evaluative procedures, which should terminate each unit, are suggested in Section 1, Chapter II, "Teaching Science by Units," and in Chapter IV, "Evaluation." A type of suggested student self-appraisal check list for Unit I is included at the end of Unit I. Similar check lists for further units may be readily constructed.

Unit I

HOW DO I DEPEND UPON MY PHYSICAL SURROUNDINGS FOR EXISTENCE?

1. *Overview*
2. *Group discussion:*
   a. What do we know now?
   b. What do we need to find out?
   c. What work plan (committees, etc.) shall we use?

Content	*Objectives*	*Learning Experiences*
A. How do living things depend on air for existence?	1. To learn how plants use carbon dioxide for the manufacture of food 2. To acquaint the student with the role oxygen plays in the utilization of food 3. To show that death results when there is a lack of oxygen available to an organism 4. To give the students an understanding of the oxygen-carbon dioxide and nitrogen cycles 5. To learn that some plants use air for seed dispersal 6. To understand that many animals use air as a transportation medium 7. To learn why ventilation is necessary 8. To understand the school's ventilation system 9. To find out what vocational opportunities there are in air conditioning and ventilation	1. View an overcrowded aquarium or one in which there is an abundance of decaying matter. Why do the fish bite the surface of the water? 2. A report from a student interested in becoming a pilot on the effects of high altitude flying and mountain climbing 3. Student Experiences a. *Problems:* How much oxygen does a class of students use during a period? Compare this with the amount of oxygen in the classroom. List some of the types of deaths caused by lack of oxygen b. *Experiments:* Show that a large portion of living things is carbon c. How can we get the best circulation of air in our schools and in our homes?

UNIT I—Continued

HOW DO I DEPEND UPON MY PHYSICAL SURROUNDINGS FOR EXISTENCE—Continued

Content	*Objectives*	*Learning Experiences*
B. How are living things dependent on water for existence?	1. To learn how plants use water in the manufacture of food 2. To show how living things use water in the assimilation of food 3. To show how water is essential to growth 4. To understand how water acts as a solvent for the wastes of the body and in dissolving minerals of the soil which are then taken in by the plants 5. To appreciate how much water there is in different organisms 6. To learn about the Pennsylvania Department of Forests and Waters 7. To learn about the water table	1. Observe a terrarium that is placed in a sunny window. 2. Study the structure of the cactus to determine how a desert plant maintains itself as far as water is concerned 3. Wet some organic material such as a prune or slice of bread and watch for molds and decay to set in 4. Set up an experiment to show the loss of water by a plant through transpiration 5. Use chart to show percentage of water in meat, eggs, etc. 6. Visit city water works 7. Experiment: Mix soil with water, filter, and boil away water to show the mineral deposits 8. Demonstrate water softening.
C. How do living things depend on soil for existence?	1. To learn what properties of soil make for good plant growth 2. To acquaint the student with the food materials plants get from the soil 3. To show how water rises from the subsoil to the region of the plant roots 4. To appreciate that many animals use the soil for their homes 5. To study soil conservation	1. Show the composition of soil by separating a sample with water 2. Set up an experiment showing capillarity. 3. Visit an eroded area. 4. Demonstrate retention of water by vegetation 5. Study formulas 4-12-4 and 5-10-5 on fertilizer bags

Content	*Objectives*	*Learning Experiences*
D. How do living things depend on light for existence?	1. To understand that light is the sole source of energy in the manufacture of food 2. To learn that animals are dependent on light for existence through the use of plant food developed in the presence of light 3. To show that plants bloom in accordance with certain light requirements 4. To learn how to light a home	1. Student report on photoperiodism 2. Group discussion 3. Prepare a chart showing the plants which prefer light or shade
E. How do living things depend on temperature for existence?	1. To learn differences between warm-blooded and cold-blooded animals 2. To show that dark objects absorb more heat than light objects 3. To learn how pasteurization and sterilization are effected by heat 4. To get an understanding of a living creature's optimum temperature 5. To learn how to adjust a Bunsen burner 6. To learn how to heat a home 7. To learn what vocational opportunities there are in heating	1. Make a list of the animals in your region that are active in the wintertime as opposed to those active only in the warmer months 2. Note how snow melts faster under a leaf 3. Use a thermometer wrapped in dark cloth to show heat absorption 4. Have a student explain the incubation of chicks 5. Group discussion on canning and other methods of food preservation 6. Grow bacteria on agar-agar. Show effect of temperature
F. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See Chapter IV): a. See page 129 of this section b. Use student self-appraisal check list c. Administer a functional unit test *Direct teaching where needed*

Student Self-Appraisal Check List for Unit I—How Do I Depend Upon My Physical Surroundings for Existence?

The following student self-appraisal check list may be mimeographed and given to biology students. Similar ones for subsequent units may readily be produced by teachers. These should motivate self-evaluation and participation and provide an overview. Items should be phrased to fit local situations. They may suggest items for homemade achievement tests.

NAME	HOME ROOM	CLASS PERIOD

To the Student:

The following items are for you to test yourself on what you are learning. You should check Y (Yes), D (Doubtful), N (No) depending upon your knowledge and understanding. Do not check Y unless you know and are sure that you know.

1. *Useful Knowledge*

	Y	D	N
a. Can you explain how plants use CO_2 to manufacture food?			
b. Do you know what part oxygen has in the use of food?			
c. Do you know why the lack of oxygen produces death?			
d. Can you diagram and explain the CO_2 cycle?			
e. Can you diagram and explain the nitrogen cycle?			
f. Can you explain why water is essential for growth?			
g. Do you know what is the percentage of water in meat? Eggs? Fruit?			
h. Can you explain what makes a well-balanced diet?			
i. Can you list some good health rules which you have learned in this unit?			
j. Can you explain what environmental conditions caused people to settle in your community?			

2. *Vocabulary*

Can you explain and use the following words and terms?

	Y	D	N		Y	D	N
a. adaptation				n. legume			
b. anabolism				o. metabolism			
c. carnivorous				p. organism			
d. cell division				q. osmosis			
e. chlorophyll				r. photosynthesis			
f. crop rotation				s. protein			
g. dietetics				t. protoplasm			
h. evolution				u. secretion			
i. excretion				v. species			
j. germination				w. transpiration			
k. habitat				x. vertebrate			
l. herbivorous				y. vitamin			
m. humus				z. zoology			

Principles and Laws

Can you list six principles or laws which explain any of the following phenomena or activities?

Fish biting at the surface of the water in an aquarium; mold forming on a piece of wet bread; water going uphill in a blotter; yellow in plants growing in semidarkness; hibernation of animals	1.	__________
	2.	__________
	3.	__________
	4.	__________
	5.	__________
	6.	__________

Daily Activities and Phenomena

Can you list six other everyday activities or phenomena which illustrate any of the following principles or laws?

Living things must struggle for existence.	1.	__________
All life comes from previously existing life.	2.	__________
Plants and animals are interdependent.	3.	__________
All nature tends to maintain a balance.	4.	__________
All plants resemble one another.	5.	__________
Plants and animals resemble one another.	6.	__________

Demonstrations

Can you demonstrate with apparatus that:

	Y	D	N
a. All living things depend on air for existence?			
b. All living things must have water?			
c. All living things depend on the soil for life?			
d. All living things require light?			
e. All living things need heat?			

What else did you learn in this unit?

a.____________________
b.____________________
c.____________________
d.____________________
e.____________________

What help did you give to what the class did in this unit?

a.____________________
b.____________________
c.____________________

Do you have any related problems which were not considered? If so, list them here.

____
____

UNIT II
HOW DO LIVING THINGS OBTAIN FOOD?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. What living things obtain their food as independent organisms?	1. To acquaint the student with the fact that green plants are the only independent living things	1. Work out the equation for photosynthesis
a. Plants	2. To learn how plants manufacture sugar during photosynthesis	2. Experiment to show a covered leaf will not manufacture sugar
	3. To acquire an understanding of solutions and osmosis	3. Experiment to show that a chlorophyll-free leaf will not produce sugar
	4. To gain an appreciation of the importanee of photosynthesis to all living things	4. Charts showing root hairs, stems, and leaves
	5. To show where the raw materials for food-getting eome from	5. Microseopie study of the stem, roots, and leaves
	6. To gain an appreciation of the strueture of a plant	6. Germinate seeds on blotters to show root hairs
		7. Set up an osmosis experiment using egg, molasses, earrot, etc.
b. Animals	1. To learn why animals are classed as herbivorous, carnivorous, or omnivorous	1. Student drawings
		2. Group discussions
	2. To acquaint the student with various methods used by animals in getting food (grazing, gnawing, tracking, trapping, ete.)	3. Pictures
		4. Speeimens of animal skulls
		5. Visit a farm or a zoo at feeding time
	3. To learn how to feed a dog, horse, cow	6. Observe amoeba feeding

Content	Objectives	Learning Experiences
2. What living things are semidependent for food-getting?	1. To show that some plants lack strong stems and must cling to other things for support	1. Use pictures to show climbing roses, grapes, poison ivy, etc.
a. Plants	2. To show that some plants lack nitrogen and, to supply this need, catch insects	2. Collect or buy a variety of insectivorous plants and grow them in a terrarium
b. Animals	1. To learn that few animals are semidependent (Drone bee is probable example)	
	2. To learn what bait to use when fishing	
3. What living things are totally dependent on other living things for food-getting?	1. To show that plants that lack chlorophyll cannot manufacture food materials for themselves	1. Make a collection of parasitic and saprophytic plants
a. Plants	2. To learn the difference between parasites and saprophytes	2. Grow some bread mold and observe its structure
	3. To learn what plants are totally dependent	
b. Animals	1. To acquaint the student with types of animal parasites and scavengers	1. Pictures
	2. To learn how to get rid of rats, flies, lice, etc.	2. Specimens
		3. Charts
		4. Student reports
4. What living things form partnerships with other living things and assist each other in food-getting?		
a. Plants	To learn what plants live together for their mutual benefit	1. Collect lichens for the laboratory terrarium
		2. Have a student bring in some clover to show the nodules containing nitrogen-fixing bacteria

UNIT II—Continued

HOW DO LIVING THINGS OBTAIN FOOD?—Continued

Content	*Objectives*	*Learning Experiences*
b. Animals	To learn what animals live together for their mutual benefit	1. Group discussion 2. Report on the protozoa in the digestive tract of the termite 3. Motion picture of a social insect 4. Get tapeworms from a veterinarian
5. Why is the maintenance of a food chain necessary for the welfare of all living things?	1. To show that no plant or animal is totally self-sufficient 2. To learn what jobs are concerned with producing and distributing food	1. Group discussion
6. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

UNIT III
HOW DO LIVING THINGS ASSIMILATE FOOD?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. What types of food are common to all living things?	1. To learn how carbohydrates, fats, and oils are used to produce energy for growth 2. To learn how proteins are used for the production of tissue-building material 3. To show how minerals are used to help produce proteins, build bones and teeth, act as regulators for the nervous system, etc. 4. To understand the role vitamins play in keeping the bodies of living things in good physical condition	1. Group discussion 2. Charts to show food values 3. Feed mice or rats on a vitamin-deficient diet
2. How are digested foods transferred to the places where they are going to be used?	1. To learn why certain physical processes such as osmosis and diffusion are necessary to food transfer 2. To show how simple living things transfer food 3. To understand how food transfer occurs in the higher plants and animals	1. Draw circulatory system of man 2. Study drawings of pith rays, sieve tubes, phloem, etc. 3. Charts 4. Frog dissection
3. How are the transferred food materials used by living things?	1. To learn how carbohydrates, fats, and oils are oxidized to produce energy for growth and how protein materials are absorbed for tissue repair or replacement in the building of new protoplasm 2. To learn how simple living things utilize oxygen 3. To understand how the more complex plants and animals utilize oxygen	1. Demonstrate simple oxygenation, showing the products produced. (Match, Bunsen burner, candle, burned sugar) 2. Observe stomata and lenticles 3. Study lungs and gills of animals 4. Collapse can with air pressure to show how lunged animals breathe 5. Demonstrate action of diaphragm with drawings, charts, apparatus, etc.

UNIT III—Continued

HOW DO LIVING THINGS ASSIMILATE FOOD?—Continued

Content	*Objectives*	*Learning Experiences*
4. Why must waste materials be eliminated if living things are to be kept efficient and in good health?	1. To learn the types of waste materials eliminated from living things 2. To learn the need for daily elimination 3. To acquaint the student with methods of disposal of gaseous, liquid, and solid waste materials from living things 4. To study waste disposal of city	1. Have students bring in advertisements from newspapers and magazines dealing with waste elimination 2. Visit sewage disposal plant
5. How do living things store excess food?	1. To learn the nature of the storage process 2. To appreciate the fact that some animals store food internally (between muscles, around organs, etc.), some externally (in hide-aways), and some not at all 3. To learn how to avoid excess fat	1. Student experiences 2. Group discussions
6. Other problems suggested by pupils	Other objectives suggested by pupils	
		Other activities suggested by pupils *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

UNIT IV
HOW DO LIVING THINGS GROW?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. The cell is the physical basis of life	1. To give the students an understanding of the structure of a cell and the difference between plant and animal cells 2. To show how cells are differentiated into tissues 3. To learn of the activities of cells, such as growth, reproduction	1. Student drawings 2. View cells under a microscope 3. Observe yeast under a microscope 4. View a cross section of a basswood stem under a microscope
2. What are the characteristics of growth?	1. To show that the appearance of new parts on an organism is the result of growth 2. To appreciate that growth results in an increase in size of a living thing	1. Time lapse photography
3. What are the phases of growth?	1. To show that living things go through three phases—the formative phase, the phase of enlargement, and the phase of maturity	1. Observe annual rings in a tree trunk 2. Microscope
4. What factors affect growth?	1. To understand that certain external factors, such as too much or too little water, have an effect on growth 2. To appreciate that the availability of food and water has a very definite effect on growth 3. To show that other living things frequently interfere with normal growth	Observe soil loam to see decaying material

BIOLOGY COMES TO LIFE

UNIT IV—Continued

HOW DO LIVING THINGS GROW?—Continued

Content	*Objectives*	*Learning Experiences*
	4. To learn that certain internal factors, such as the endocrine glands and hereditary characteristics, influence growth	
	5. To understand adolescent development	
	6. To develop good health habits: food, rest, recreation	
5. Why do living things unable to meet the demands of their environment perish?	1. To show that extreme conditions of the environment, the activities of other living things, diseases, etc., bring about the death of an individual organism 2. To appreciate that death appears in several forms—death of parts (loss of leaves, bark, etc.) and death of the whole organism 3. To study life expectancy	1. Group discussions on life adjustment: a. Work b. Health c. Citizenship d. Choosing a mate and making a home e. Thrift f. Use of science g. Appreciation—culture h. Use of leisure i. Getting along with others j. Expressing ideas clearly
6. What happens to organisms when they die?	To show that living things are a part of a cycle—that materials used by living organisms to sustain life are returned to the air and soil through decay	
7. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

Unit V

HOW DO LIVING THINGS MAINTAIN THEIR KIND?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. "All life comes from life"	To show evidence that all living things come from living things	1. Student reports on spontaneous generation, Pasteur, Redl, etc.
2. "Like begets like"	To show that parents produce offspring similar to themselves	2. Student Projects a. Plant a vegetable garden—show produce to class b. Prepare a flower garden—show results to class
3. How do simple plants and animals reproduce?	1. To show that the simplest type of reproduction is asexual 2. To learn what the various kinds of asexual reproduction are:—simple cell division, fragmentation, sporification, and parthenogenesis	1. Charts 2. Student drawings 3. Slides 4. Films 5. Specimens 6. Microscope
4. How do the more complex plants and animals reproduce?	1. To show that the highest type of reproduction is sexual 2. To learn how to avoid venereal disease 3. To understand the difference between conjunction and fertilization	1. Talk by parent or school physician 2. View film "Human Growth" 3. Show with microscope: a. Reproduction by fission (paramecium) b. Budding (yeast) c. Spores (puffball) 4. Have students make growths from cuttings 5. Study the life history of mosses and ferns

Content	*Objectives*	*Learning Experiences*
5. What is the most complex type of reproduction?	To learn that the most complex type of reproduction is a combination of asexual and sexual types, resulting in an alternation of generations	
6. How do parents provide for their offspring?	1. To learn how plants give their offspring the protection of a seed coat and the means—parachutes, hooks, etc.—of finding a place to grow	1. Make a collection of seeds to study the various methods of seed distribution among plants 2. Student experiences
	2. To show that living things provide for their young in such a manner that they can get a good start in life	
	3. To learn how animals by the placement of eggs provide for their young	3. Reports on the effects on children of: a. Overly strict parents b. Inconsistent parents c. Overindulgent parents d. A clinging mother e. A brusque father
	4. To learn how to rear children	
	5. To appreciate that there is a relationship between the number of young produced and the amount of parental care given the offspring	4. Reports on the development needs of: a. Infancy b. Childhood c. Adolescence
7. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

Unit VI
HOW ARE LIVING THINGS CLASSIFIED?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. Why is there a need for some system of classification of plants and animals?	To show the need for systematizing the grouping of living things	1. Group discussion 2. Report on Linnaeus 3. Report on achievements of individuals of various races and creeds 4. Report on the interdependence of people
2. What are the bases used for the classification of living things?	1. To learn that living things are classified according to structure (taxonomy), activities (ecology), and groupings for study (ornithology, herpetology, etc.) 2. To learn what similarities there are between different races	
3. Why is it important that all nationalities use the same name for a plant or an animal?	1. To show that common names are very inadequate 2. To learn why Latin names are given to living things 3. To understand that the language of classification is a universal language 4. To learn how a living thing gets its scientific name 5. To learn what group names are used in classification (kingdom, phylum, class, etc.) 6. To appreciate that the system used universally is a binomial system	1. Discussion of some common names known to the students 2. Construct a key for the identification of some common plants and animals 3. Prepare a list of common names of familiar plants and animals 4. List major taxonomic divisions 5. Prepare a terrarium

Content	*Objectives*	*Learning Experienees*
4. How are plants classified systematically?	To learn the various groupings into which plants are placed	Have students bring in plants representing the various plant groups
5. How are animals classified systematically?	1. To give the students an idea of the characteristics of the various animal groups 2. To show the student how he can find out to what group an animal belongs 3. To acquaint the student with the use of a key in identifying animals	1. Keys 2. Pictures 3. Student reports
6. What advantages are there in a system that classifies living things systematically?	To show that a common classification system is important to the understanding of the differences among living things	Group discussion
7. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

UNIT VII

HOW DO LIVING THINGS REACT TO THEIR ENVIRONMENT?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. What properties does protoplasm have that cause it to respond to a stimulus?	To learn that protoplasm has certain characteristics—irritability and the ability to respond to stimuli	1. Microscopic observation 2. Drawings 3. Charts 4. Observe protozoa in salt water 5. Check student reaction time in stopping a car
2. What are the types of stimuli to which protoplasm responds?	To acquaint the student with the types of stimuli affecting living things—light, touch, gravity, temperature, water, minerals, etc.	
3. What are the types of responses living things can make?	1. To appreciate the differences of the various types of responses of living things (tropisms, instincts, reflexes, conditioned reflexes, trial and success, and reasoned responses) 2. To understand what causes fear, anger, etc. 3. To learn how to get the best responses from people 4. To learn how to control the emotions 5. To learn how to study	1. Demonstrate thigmotropism with a sensitive plant 2. Use plants to show thigmotropism, chemotropism, geotropism 3. Have students make original experiments to show responses to stimuli 4. Experiments with plant and animal responses 5. Demonstration of the time factor in reflex action 6. Discussion of student experiences with conditioned reflex actions 7. Talk to class by a salesman 8. Class experiments on the retention of factual material

Content	*Objectives*	*Learning Experiences*
4. How does the type of structure of a living thing determine its level of responses?	1. To show the student that the more complex organisms have more complex responses 2. To give the student an understanding of the basic structure involved in stimulus-reacting cycle 3. To learn about vocational opportunities 4. To show the difference between the diffuse and central nervous systems 5. To show how a person reacts as a whole to his environment	1. Specimens 2. Charts 3. Student drawings 4. Talk to class by a psychologist 5. Construct a maze for a hamster, rat, mouse, etc.
5. How is man different from all other living things in his ability to master his environment?	To show that man has ability to solve problems; make or break habits; transmit ideas; master time, space, and motion; plan for the future, and develop a moral sense	1. Group discussion on "How are habits formed?" and "Is a dog intelligent?" etc. 2. Demonstration with a dog 3. Group discussion on: "Why Stay in School?"
6. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

Unit VIII

HOW ARE LIVING THINGS FITTED TO THEIR ENVIRONMENT?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. What is a habitat?	To learn that living things are best suited to a habitat	
2. How are living things fitted to live in a water habitat?	1. To show that hydrophytic plants have characteristics that fit them to live in water 2. To show that water animals are constructed to fit them to a water habitat	1. Set up a balanced aquarium 2. Study the animals in the classroom aquarium 3. Arrange a field trip to a stream or pond Teach nonswimmers to swim 4. Collect water plants and grow them in the classroom 5. Pictures
3. How are living things fitted to live on land?	1. To appreciate the difference between mesophytic and exophytic plants and animals 2. To learn how land plants and animals differ from those that live in the water	1. Charts 2. Specimens 3. Student experiences 4. Pictures
4. How does the external appearance of living things fit them to their environment?	1. To acquaint the student with the various types of protective coloration (concealing coloration, confusing coloration, and seasonal change) 2. To learn animal types that mimic plants or other animals for their protection 3. To learn what animals use warning coloration	1. Pictures 2. Specimens 3. Report on protective coloration 4. Observe ancient plants and animals in a museum 5. Collect fossils 6. Observe films on prehistoric life

Content	*Objectives*	*Learning Experiences*
5. What are the factors that enable a living thing to survive the struggle for existence?	1. To show that all living things, in order to survive, must compete successfully with their environment 2. To learn that plant and animal forms of today have evolved by gradual stages from earlier different forms 3. To acquaint the student with some of the plants and animals of past ages 4. To learn how the environment has changed during the past century	1. Student report on the chestnut blight 2. Report on Charles Darwin 3. Group discussions on the changing world today 4. Pictures 5. Talk by history teacher
6. What factors have contributed to the present geographic distribution of plants and animals?	1. To show that the geographic distribution of plants and animals is due, in part, to land bridges linking continents 2. To learn that climate, light, moisture, movements of air, soil conditions, mountains, seas, etc., influence the geographic distribution of living things	Maps
7. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

Unit IX
WHY MUST I CONSTANTLY ADJUST MYSELF TO MY ENVIRONMENT?
Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. What constantly causes many living things to migrate? a. Plants	1. To show that plants migrate more than most animals 2. To learn that spores, seeds, underground stems, etc., fit plants for migration 3. To learn what agents assist in plant migration	
b. Animals	1. To show that animals differ considerably in their migration habits 2. To understand that many herbivorous animals remain near the places where they were born 3. To learn that carnivorous animals range more widely than herbivorous species 4. To show that migration movements are of several types 5. To study the migration of the local population	1. Student report on lemmings, etc. 2. Have the students make a list of the animals in their district that have come from other districts 3. Conduct a class survey on migration: a. How many students have moved into the locality? Why? b. How many relatives have left the locality? Why? c. How many students expect to leave the locality? Why?
2. Migrating living things invade new territory	1. To learn that certain factors limit invasion (mountain ranges, water, deserts, soil conditions, predators, etc.) 2. To show that an invasion, to be successful, must have a good chance for competition between the invader and the plants and animals already established in the territory 3. To understand why people may adjust better in another place	1. Student experiences—reports a. Difficulty of adjusting in a new school to: (1) Teachers (2) Pupils (3) Community b. Difficulty of adjusting to older people c. Difficulty of finding part-time work

Content	*Objectives*	*Learning Experiences*
3. How does the invasion of outsiders change the habitat of an area?	To show that successful invaders compete with each other and with the established residents of an area	
4. What do we mean when we say that an area is at its climax?	To appreciate that given time, plant and animal growth reach climax conditions, which, when complete, represent the best expressions of their environment in terms of what can grow in them under the best of favorable conditions	A trip into the field
5. How does the changing environment upset the existing climax?	To show the succession of plants and animals from glacial lake to climax forest, and from bare soil to climax forest	Pictures
6. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils*
		Continuous use of references
		Evaluation: (See p. 129)
		Direct teaching where needed

UNIT X
WHAT ARE THE WAYS IN WHICH I CAN USE LIVING THINGS?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. What living things does man use as food?	To acquaint the student with the multitude of living things he uses for food, clothing, medicines, poisons, commercial materials, recreation, and for aesthetic reasons	1. Make a list of some of the plants and animals man uses for food, clothing, etc. 2. Talk by home economics teacher on how to purchase, store, and prepare food
2. What living things does man use as food adjuncts?		
3. What living things does man use for medicines or poisons?	1. To give the student an appreciation of the multitude of medicines, astringents, vaccines, serums, hormone extracts, venoms, etc., that we get from living things 2. To present to the student material relevant to the tobacco habit 3. To acquaint the student with the alcohol problem of today	1. Talk by school physician 2. List drugs used now that were not available a generation ago 3. Talk by member of Alcoholics Anonymous
4. What living things does man use as commercial materials?	To show the student where we get fuel, dyestuffs, lubricants, plastics, furs, hides, horns, shells, etc.	Specimens

Content	*Objectives*	*Learning Experiences*
5. What living things does man use as a source of recreation?	1. To show how man can use nature in many ways for a leisure time activity 2. To learn that leisure is necessary for adjustment	1. Using a map, label State forest areas, hunting areas, good fishing areas, etc. 2. Make a list of the birds seen and identified by the students throughout the year 3. Reports on: a. Hunting and fishing laws b. Game protection c. Safety in the woods; first aid
6. What living things does man use for aesthetic purposes?		
7. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

UNIT XI
HOW CAN I IMPROVE LIVING THINGS?
Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. The basis for the improvement of living things is variation	1. To show how offspring vary from their parents, making it possible for man, through selection, to improve his domesticated plants and animals	1. Talk by farm agent 2. Count the seeds in a number of pods Make a graph to show normal variation 3. Have students read for one minute Each student counts the words read Plot on graph for the class. Results show normal variation 4. Plot test scores
2. How can we use artificial selection as a means of bettering our domesticated plants and animals?	1. To show that by proper selection we can obtain the best stock for perpetuation 2. To learn what a boy or girl should look for in a mate	
3. How can crossbreeding be used as a means of getting desired characteristics?	1. To give the student an understanding of how living things inherit their characteristics 2. To gain an appreciation of the works of Gregor Mendel 3. To study genes and chromosomes	1. Student report on Mendel 2. Work out some simple heredity problems 3. Make charts showing the inheritance of characteristics 4. Breeding of laboratory animals 5. Pictures 6. Review cell structure
4. How can man improve living things by searching for new and better forms of plant life?	To show that by the cultivation of plants and the improvement of lake and stream conditions, as well as the living conditions of domesticated animals, living things can be improved	1. Work some simple genetic problems. Show monohybrid and dihybrid crosses 2. Show how sex-linked characteristics are transmitted, how sex is determined, continuous and discontinuous variation, etc.

Content	*Objectives*	*Learning Experiences*
5. How can man improve living things by searching for new and better forms of animal life?	To acquaint the student with the activities of our government, universities, and private individuals in their attempt to better our stock of plants and animals by replacement with newer and better forms	1. Debate on: "The Relative Importance of Heredity and Environment" 2. Report on Luther Burbank
6. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

UNIT XII

WHY MUST I CONTROL MY ENVIRONMENT IN ORDER TO ASSURE SATISFACTORY EXISTENCE?

Overview by the teacher and planning with pupils

Content	*Objectives*	*Learning Experiences*
1. What do we mean when we say that the only constant in nature is change?	To appreciate that the natural world has always been in a state of change	Talk by a geologist
2. What is meant by the balance of nature?	To show that, left undisturbed by man, nature maintains a favorable balance among living things and their related natural resources	1. Pictures 2. Talk on the wilds by a traveler
3. How has man, wherever he has settled, upset the balance of nature?	To understand that man has brought about an unbalanced state of affairs in most of the world	1. Students make posters advocating conservation of natural resources 2. Government pamphlets 3. Talk by a conservationist
4. What effect has the unwise use of our natural resources had on our economy?	1. To appreciate that the economic and social structures of our society are affected by our depleting natural resources 2. To understand that nations rise and fall according to their possession and use or lack of natural resources 3. To learn about vocational opportunities	1. Organization of a conservation club 2. Talk by a counselor
5. How can man, at least partially, restore a favorable balance of nature?	To understand that if life is to exist on a satisfactory basis, man must help restore a workable balance of life among living things and between them and their related natural resources	

Content	*Objectives*	*Learning Experiences*
6. In regard to his environment, what must man do if he is to survive and multiply?	1. To show the student that unplanned land use leads to land misuse 2. To point out that the highest development of man's control of his environment is that of planning the use of land on a national scale	Panel discussion
7. Other problems suggested by pupils	Other objectives suggested by pupils	*Other activities suggested by pupils* *Continuous use of references* *Evaluation:* (See p. 129) *Direct teaching where needed*

PREPARING A CULTURE

Unit XIII—A Life Problem Unit

HOW WILL BIOLOGICAL-MEDICAL RESEARCH HELP ME TO LIVE LONGER?

1. OVERVIEW BY TEACHER
2. PUPIL-TEACHER PLANNING
3. OBJECTIVES

   a. To develop an appreciation of the part biological and medical research plays in making our lives longer, healthier, and happier.

   b. To gain an understanding of the contributions of animal experimentation to man and animals.

   c. To develop a realization that if medical and biological science is to progress—if we are to develop cures for cancer, heart disease, poliomyelitis, etc., science must be permitted to study life in order to protect life.

   d. Other aims developed by class discussion.

4. INTRODUCTION (OVERVIEW)

   Medical research or biological investigation is the study of body functions and the study of diseases.

   Medical research has made phenomenal contributions to man's health and welfare. From such endeavor has come most of our knowledge

about nutrition, function of body organs, use of drugs, and control of diseases. Animal studies have resulted in the control of diabetes, smallpox, pellagra, scurvy, rickets, beriberi, diphtheria, typhoid fever and malaria. Many new and startling surgical procedures developed in the laboratory are now saving countless lives.

Each one of us has benefited from biological investigation of both plants and animals. Too often we know only of the successful results of such investigations and little of the trials and tribulations involved in the quest for new drugs or the contributions animals have made in protecting and prolonging our lives.

The source of scientific knowledge on the functions of the human body is the result of experimental research on animals. Such research has proved equally beneficial to animals.

Biological experimentation is essential for the practical application of a great deal of present medical knowledge in the prevention or cure of disease. Animals produce antitoxins for us; they are essential in the discovery and standardizing of new remedies. They are necessary for the diagnosis of some forms of tuberculosis. The modern story of foods, nutrition, and the known disorders of nutrition would be largely gaps and guesses, except for the services of the rat, the pigeon, and the dog. We would be greatly hampered in applying the known facts to society, were society to stop the doctor and the biologist from the humane use of animals in the scientific service of man.

Animal experimentation is essential for further progress in biology and medicine. Experimentation has certainly proved its value in the biology and medicine of yesterday and today. But what about tomorrow? Do we know it all? Or, if not, cannot we find the missing answers by intuition, inspiration or logic? Intelligent and humane use of all species of animals will be necessary on the road to a fuller understanding and attainment of better health.

The use of animals is of continuous and increasing importance in the training of the doctor and the biologist of the future.

The search for new and improved methods of controlling diseases in man and animals will never end. The life lost today may be saved tomorrow, thanks to men who have dedicated their lives to the conquest of disease.

5. CONTENTS

a. Why is Biological and Medical Research Important?

(1) Basis for present knowledge

(2) Source of future knowledge

b. Beginning of Modern Research

(1) Knowledge of anatomy
Andreas Vesalius—William Harvey—Anton van Leeuwenhoek

(2) Function of body organs

(3) Animal experimentation

c. Importance of Botany to Medicine

(1) Drugs primarily of vegetable origin
(2) Morphine–quinine–digitalis–cocaine
(3) First tested on animals–still tested on animals

d. Testing the Safety and Effectiveness of New Discoveries

(1) On various species of animals
(2) Proof and acceptability
(3) Establishing standard dosage
(4) Maintaining standards of all drugs

e. Advance in Modern Surgery Perfected Through Animal Experimentation

(1) Blue baby operation
(2) Blood vessel, bone, and nerve grafting
(3) Stader splints
(4) Lung, brain, and heart operations
(5) Technique always perfected on animals before humans

f. Health Heroes and Research

(1) Louis Pasteur–germ theory of disease
(2) Edward Jenner–vaccination against smallpox
(3) Walter Reed–conquest of yellow fever
(4) Robert Koch–science of diseases
(5) Paul Ehrlich–the birth of chemotherapy

g. Modern Medicine and Longer Life

(1) Insulin–over a million people being kept alive today because of insulin
(2) Iron Lung–saves thousands of polio victims
(3) Penicillin–a dramatic decline in pneumonia deaths
(4) Sulpha drugs–compounded in the laboratory and tested on animals
(5) Atomic sickness–knowledge acquired by testing dogs

h. Animals Benefit from Medical Research

(1) Anthrax vaccine
(2) Animal anesthesia
(3) Sleeping sickness serum
(4) Brucellosis testing
(5) Stader splints

i. The Debt of the Soldier to Animal Experimentation

(1) Mortality of battle casualties treated in medical installations
 a. World War I–8-12 per cent
 b. World War II–3.9 per cent

(2) Medical progress due to animal experimentation between World War I and World War II saved the lives of over 25,000 American boys

j. Thanks to Animals

(1) Scurvy has lost its terror
(2) Today diphtheria seldom strikes
(3) Surgery is no longer agonizing
(4) Smallpox can be conquered
(5) Blue babies can now be saved
(6) We know the sulphonamides are safe and efficient
(7) The iron lung was perfected
(8) Powerful heart remedies can be given with safety
(9) If atomic medicine is successful

k. Medical Progress in Danger

(1) Difficulty of obtaining suitable experimental animals
(2) Thousands of unwanted and unclaimed dogs in public pounds unavailable for research
(3) The antivivisection movement
(4) Research on cancer, heart disease, poliomyelitis, etc, curtailed by lack of animals

6. ACTIVITIES

a. Preview Questions

(1) How do we know the function of each body organ?
(2) Why are drugs dangerous? How do we know?
(3) How do we know certain drugs will kill certain diseases?
(4) How would you prove germs cause disease?
(5) Where do we get smallpox vaccine?
(6) Why are not all drugs safe to use?
(7) Why are operations on blue babies necessary?
(8) How would you have your surgeon trained?
(9) Why should diabetics owe their life to dogs?
(10) What animal was used to perfect the iron lung?
(11) What training do veterinary surgeons need?
(12) In what way do animals benefit from animal experimentation?
(13) Why were there fewer deaths from wounds in World War II than in World War I?
(14) How will we learn if atomic medicine can serve mankind?
(15) Are cancer research and heart research being curtailed? How? Why?

b. Problem Situations

(1) *Medical progress depends upon animal experimentation*
(a) How could you prove conclusively that the frog has a heart?

(b) What would be your procedure in proving that a new drug would be safe for humans?

(c) How could you prove that protein is essential to dogs' diets?

(2) *A person born today can expect to live 19 years longer than in 1900*

(a) Why do people live longer today than in 1900?

(b) What are some of the new chemicals used in prolonging life?

(c) Can cancer be cured? How do you know?

(3) *Immunization protects the child against smallpox, diphtheria, whooping cough, scarlet fever, etc.*

(a) Why is vaccination compulsory?

(b) How is vaccine tested?

(c) What is the Schick Test? Dick Test?

(4) *Countless diseases have been conquered as the result of medical research*

(a) Why is experimenting on humans dangerous?

(b) Why should animals first be used to test drugs and new surgical procedures?

(5) *The dog is the only animal which can be used in certain fields of research because his physiological and digestive processes are very similar to those of man*

(a) Ask your doctor why the dog had to be used in perfecting the blue baby operation.

(b) How does a dog's digestive tract differ from a bird's?

(c) How does man's digestive tract differ from a cow's?

c. **Class Activities**

(1) Request a physician to discuss the value of animal experimentation to medical progress.

(2) Assign three members of the class to visit the hospital laboratory and to report its function to the class.

(3) Have a delegation interview a dairyman to find out how he protects his herd from diseases.

(4) Request a local veterinarian to discuss how animal experimentation has helped animals.

(5) Assign members of the class to interview a local pharmacist to find out how he knows the prescription he mixes will be safe to use.

(6) Assign a member of the class to write to one of the medical schools in Pennsylvania to inquire if the animals they use in research are humanely treated.

d. Review

Be able to pronounce, spell, and use correctly, the following words:

infantile paralysis	morphine	brucellosis
diabetes	chemotherapy	mortality
beriberi	grafting	vivisection
surgical	Stader	diabetics
biological	penicillin	immunization
Vesalius	anesthesia	veterinarian
Van Leeuwenhoek		

e. Additional Suggestions for Individual Work

(1) Compare the circumstances under which operations were performed in colonial times with the present.

(2) Compare the incidence of smallpox in the 17th Century with that in the 20th Century.

(3) List as many reasons as possible why the average span of life has been increased 19 years in the past 50 years.

(4) List all the illnesses each member of your family has had during the past year. List opposite each illness, the drugs or surgery used in restoring health. Check with your family physician to see what part animal experimentation played in treating your own family.

(5) Ask all those who live on farms to list the diseases that have affected their stock during the past year. What treatments were prescribed? Were any perfected through animal experimentation?

f. References:

(1) Smallwood, W. M.; Reveley, Ida L.; Bailey, Guy A.—*New Biology,* New York; Allyn and Bacon, 1934.

(2) Silverman, Milton—*Magic in a Bottle,* New York; The Macmillan Company, 1948.

* (3) Scheele, L. A., Surgeon General, *Care of the Dog Used in Medical Research;* Supplement 211, Public Health Reports, 1949. U. S. Government Printing Office, Washington, D. C., 1949.

* (4) *Animal Studies,* National Society for Medical Research; Chicago, Illinois, 1949.

* (5) *From 606 to Sulpha,* National Society for Medical Research; Chicago, Illinois, 1949.

* (6) *Which Is Your Choice ?,* National Society for Medical Research; Chicago, Illinois, 1949.

* (7) *85 Versus 8,* National Society for Medical Research; Chicago, Illinois, 1949.

* (8) Joslin, Elliott P., *Doctors—Diabetes and Dogs;* Reprint from *Hygeia,* February, 1937; American Medical Association; Chicago.

* (9) *Blue Baby Research,* Reprint from *Life,* March, 1949.

* (10) Manchester, William, *The Great Vivisection Dog Fight;* Reprint from *Look,* May, 1950.

* Available from The Medical Society of the State of Pennsylvania, 230 State St., Harrisburg, Pa., free, or the National Society for Medical Research, 25 East Washington St., Chicago 2, Illinois.

*(11) Ivy, A. C., and Zobel, A. F., *Are Animal Experiments Needed ?;* Reprint from American Pharmaceutical Association *Journal,* Vol. 7, No. 9; September, 1946.

*(12) Cutler, E. C., M. D., *The Debt of the United States Army Soldier to Animal Investigation;* Reprint from Harvard Medical Alumni Bulletin, Vol. 20, No. 3; April, 1946.

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*(14) Yahraes, Herbert, *Science Tries You Out on the Dog;* Reprint *Popular Science,* February, 1949.

*(15) Harris, A. S., *Medical Progress in Danger—Please Help;* Reprint Academy of Medicine of Cleveland; May, 1947.

*(16) Wylie, Philip, *A Peek Inside the Antivivisectionists;* Reprint, Off My Chest column; November 9, 1946 and December 4, 1946.

*(17) Harrison, J. W., *Antivivisection Propaganda Handicaps Science,* Reprint, *Food-Drug-Cosmetic Law Quarterly;* September, 1947.

g. Visual and Auditory Aids[1]

(1) *Films*

(a) "Man's Greatest Friend" (MGM)—10 minutes
(b) "They Live Again" (MGM)—10 minutes
(c) "One Against the World" (MGM)—10 minutes

(2) *Transcriptions*

"The Story Behind the Discovery"

Thirteen 15-minute transcriptions

1. "Your Life's Blood"	pernicious anemia
2. "The Sheep at Melun"	Louis Pasteur
3. "The Invisible Enemy"	poliomyelitis
4. "The Cat and the Mouse"	asthma
5. "Almost Human"	anesthesia
6. "The Gangster and the Rodent"	cancer
7. "The Perfect Specimen (R. H. factor)"	R. H. factor
8. "The Dog He Never Had"	diabetes
9. "The Cow and the Bell"	Jenner
10. "A Blow to the Heart"	heart surgery
11. "The Lucky Accident"	penicillin
12. "Two Mad Dogs"	rabies
13. "Bright Red Miracle"	sulphonamides

(3) *Posters*

Thanks to Animals—posters
Series of 12—(8½″ x 11″)

7. PROBABLE OUTCOMES

Attitudes

(1) An appreciation of the need and importance of medical research.
(2) An understanding of why new medical discoveries must first be tested on animals.

[1] Note: The above visual and auditory aids may be obtained FREE through The Medical Society of the State of Pennsylvania, 230 State St., Harrisburg, Pa.

(3) A realization that animals used in laboratories are humanely cared for.
(4) That only 5% of animals used in experimental work are subjected to surgery.
(5) Medical research must be encouraged to continue unhampered by minority groups if we are to conquer diseases such as cancer, heart disease, poliomyelitis, and the common cold.

8. EVALUATION

See Chapter IV and notes in the introduction to this section, p. 129.

Unit IV—A Life Problem Unit

HOW CAN WE RAISE PLANTS IN THE ABSENCE OF SOIL?

Overview by teacher and planning with pupils

1. OBJECTIVES

a. Central Objective

The ability to raise plants by hydroponics

b. Contributory Objectives

1. Appreciation of the value of raising plants by hydroponics
2. Understanding the methods of hydroponics
3. Knowledge of the construction of hydroponic equipment
4. Skills in raising the plants
5. Knowledge of the varieties of plants suitable for hydroponics gardening

c. Indirect Objectives

1. A desire to raise one's own plants by hydroponics
2. Appreciation of plant development and growth day by day
3. A desire to produce sturdier and better bearing plants
4. Significance of hydroponics in the present world food shortage

2. PRESENTATION

A home is never quite complete unless it is properly landscaped. A velvety lawn, well-placed trees and shrubs, and artistically planned flower gardens are almost as necessary as the house itself. Almost everyone, at some time or other, has engaged in gardening.

We are going to learn about a new type of garden you can all make. The flowers and vegetables will be grown by hydroponics. This is the art of growing plants without soil. Chemical solutions can supply the same nutrients that are supplied by the soil. Water culture was practiced at least 260 years ago.

You will find this type of gardening much fun. You will be able to carry out your gardening in your bedroom window. It is exciting and satisfying to watch your plants grow from seed or seedlings to the stage of maturity where they serve a useful purpose. Few things can be

more thrilling or more satisfying than to watch carefully and nurture patiently a flower seed from the day you plant it to the day it produces a beautiful flower.

3. PRIOR MASTERIES

This unit presupposes that the students for whom it is intended have had a course in biology, also that they have a fair knowledge of gardening, chemical terms, chemicals, and manipulation of chemical apparatus.

4. THE PRETEST

a. What does the word "hydroponics" mean to you?
b. What type of gardening have you done?
c. Have you ever consulted a seed catalog?
d. In the following list, check the vegetables, fruits, and flowers you like. Double check those you think you would enjoy raising.

Vegetables and Fruits		*Flowers*	
(1) tomatoes	(6) lettuce	(1) carnation	(7) gardenia
(2) potatoes	(7) cucumbers	(2) ageratum	(8) Bermuda lilies
(3) corn	(8) string beans	(3) azalea	(9) snapdragons
(4) beans (lima)	(9) cantaloupe	(4) lily of the valley	(10) sweet peas
(5) celery	(10) watermelon	(5) rhododendron	(11) columbine
		(6) speedwell	(12) calla lilies

e. Have you ever read material on the subject of soilless culture? If you have, write a brief summary of your knowledge of it.
f. Write a brief explanation on the construction of a "growing flat."

5. ACTIVITIES DESIGNED TO DEVELOP EACH OF THE CONTRIBUTORY OBJECTIVES IN ITS RELATION TO THE CENTRAL OBJECTIVE

a. Contributory Objective 1—*Appreciation of the value of raising plants by hydroponics*

(1) *Pretest*
   (a) Is it more economical to use chemical nutrients than organic fertilizers?
   (b) Is the food produced of better quality?
   (c) Can the culture be carried on at home?
   (d) Is there better control over insect pests and diseases?
   (e) Do plants grow better by hydroponics?

(2) *Learning Activities*
   (a) Read several reference books on the value of raising plants by hydroponics. After you have completed the readings, ask yourself the following questions:
      (1) Of what value is hydroponics to the average person?
      (2) Of what value is hydroponics to the community?
      (3) How has hydroponics aided in solving the world's food shortage?
   (b) Contact several growers and obtain their opinions.

(3) *Check Test* (written)

(a) Secure pretest 1 and complete it in the light of what you have learned.

(b) Mark the following statements true (T) or false (F):

(1) ( ) Foods can be grown everywhere, in or out of season, by hydroponics.

(2) ( ) Generally, larger yield can be obtained by hydroponics than by soil culture.

(3) ( ) Several crops can be grown during one year.

(4) ( ) Poorer quality of food is produced by hydroponics.

(5) ( ) Hydroponics has not aided elimination of food shortage throughout the world.

b. Contributory Objective 2— *Understanding the methods of raising the plants*

(1) *Pretest*

(a) Name the methods employed.

(b) What is the outstanding feature of each one?

(c) What precautions must be employed?

(2) *Learning Activities*

(a) Consult several texts, bulletins, and periodicals on hydroponics.

(b) Briefly outline the various methods and the characteristics of each which distinguish it from the others.

(c) Notice the construction of the tanks used in each.

(d) Which one of these methods do you intend to follow in your unit?

(e) Develop the plan for the method you expect to use.

(f) During the week end visit a hydroponic hothouse, and inquire as to their method or methods.

(3) *Check Test* (written)

(a) Answer questions 1 and 2 of the pretest. What changes would you make?

(b) Is it imperative that precautions must be employed in the different methods? Give opinions.

(c) What significance does construction of the tank have upon the method of raising the plants by hydroponics?

(d) Does the type of plant determine the method to be used? Explain fully.

c. Contributory Objective 3— *Knowledge of the construction of hydroponic equipment*

(1) *Pretest*

(a) Give a summary of construction and equipment for large scale operation such as would be used in a 30′ x 200′ hothouse.

(b) Is it necessary to build a glass hothouse over the hydroponics tanks?

(c) What is the equipment needed for a small scale operation?

(d) What equipment would you need or need to make in order to begin your unit?

(2) *Learning Activities*

(a) Look up plans in a laboratory manual and obtain the dimensions for the construction of the tank. If it can be made of wood, contact the lumber company and obtain the type of wood that is required.

(b) Ask permission of your manual training teacher to construct the tank. Make sure all seams are watertight.

(c) Secure your filler material and sterilize it by heating with steam or baking it in an oven.

(d) Visit a commercial hydroponic hothouse and note the plumbing, electric wiring, thermostatic controls, ventilating system, pumping system. Ask the operator whether sunlight is necessary.

(3) *Check Test* (written)

(a) Answer all the questions in the pretest.

(b) Give a detailed explanation of the construction.

(c) Would it be proper to use flower pots, jars, cups, etc., for tanks? Explain.

(d) What type of filler will you use for your unit. Explain fully.

d. Contributory Objective 4— *Skills in raising the plants*

(1) *Pretest* (none is needed)

(2) *Learning Activities*

(a) Consult several books and obtain the chemical ingredients of the nutrient solutions that are used in the hydroponic experiment. Catalog each type and mark down the weights of substances required.

(b) Select the nutrient best suited for your type of plants. Obtain the chemical from the stock shelf and weigh out the necessary chemicals. Follow directions for mixing as prescribed by your recipe.

(c) Study various methods of supporting your plants by visiting ordinary hothouses in your community. Notice whether they use wires, strings, sticks, etc. Select method you would employ in supporting the plants.

(d) Visit a hydroponic hothouse and select the best procedure of feeding nutrients to your plants. Record the frequency of daily feeding.

(e) Understand well the procedure and manipulations of testing your food nutrients. Consult textbooks on this phase of the work.

(3) *Check Test* (practical)

The instructor will himself check the types of chemicals used by having the student display each chemical before he mixes his solutions. Unless proper procedure is used the addition of the chemical at the wrong moment may form an insoluble precipitate, thus indicating lack of care in following the order of mixing.

After the plants are growing, the instructor can check the support method used and how neatly and well the support was accomplished.

The instructor will watch several times the act of feeding the plants by the learner. Any correction can be made at this point in the procedure. At this point also the instructor can check the student's testing ability and manipulation of testing equipment and the results obtained.

e. **Contributory Objective 5**—*Knowledge of the varieties of plants suitable for hydroponic gardening*

(1) *Pretest*

(a) What is meant by the pH value?

(b) Of what importance is the pH number in selection of the type of plants that can be grown?

(c) Have you consulted a seed catalog and chosen the seeds you want to plant?

(d) How long must the plants grow and develop before a flower or a fruit or a vegetable is produced?

(2) *Learning Activities*

(a) Study books on the type of plants that have been raised successfully by hydroponics. Look for the information of pH value and its importance in the selection of the right type of plant to be raised.

(b) Visit your local hydroponic hothouse and inquire as to the use of the pH value in raising plants. Check to see

whether there are plants there which you would like to raise.

(c) Ask adults whether they ever used pH values in ordinary home gardening.

(3) *Check Test* (written)

(a) Define pH value.

(b) Does the pH value determine the ingredients of the nutrient solution?

(c) Here are listed the flowers, fruits, and vegetables. Place them under the correct pH value rating. The ratings are pH 4-5, pH 5-6, pH 6-7.

ageratum	lima beans	alyssum
azalea	candytuft	anemone
lily of the valley	lupin	aster
potato	watermelon	string beans
rhododendron	calla lilies	begonia
speedwell	Bermuda lilies	calendula
gardenia	snapdragons	cantaloupe
columbine	chrysanthemum	petunia
coreopsis	nasturtium	tomato
gaillardia	sweet peas	carnation

6. FINAL EXAMINATION OF THE CENTRAL OBJECTIVE—
(This is a written test.)

This test is to be given upon the maturation of the plant or plants grown by the learner. Its purpose is to measure attainment of the central objective of the unit, viz., ability to raise plants by hydroponics.

Part A.

Following is a list of true or false statements; mark true statements with a *T* and false statements with an *F*.

1.___Hydroponics is a method of growing plants in water to which chemicals are added, rather than soil.

2.___Plants grown by hydroponics are more sturdy and bear "quality" products.

3.___Aeration of the food nutrient is unnecessary.

4.___Plants are raised with great difficulty in chemical solutions.

5.___When mixing the nutrient solution any quantity of the chemical may be used without harm.

6.___The pH factor is of little significance in the raising of plants.

7.___Plants grow very rapidly when raised on chemical nutrients.

8.___Air and sunlight are not required by hydroponically raised plants.

9.___Almost any type of hollow ware may be used as a hydroponic tank.

10.___It is more economical to raise plants by chemical soils.

Part B.

1. Briefly summarize the following methods of hydroponics:
   a. Old New Jersey Method.
   W. F. Gericke's Method
   Present New Jersey Method
   The Withrow Method
   b. Which method did you select, and why?

2. Give a detailed discussion on the following:
   a. Chemical composition by weight of your nutrient solution.
   b. How is feeding of the plant controlled?
   c. Precautions in making and using nutrient solutions.
   d. How are plants supported?

3. Explain the construction of your hydroponic tank.

Upon completion of written test, the instructor goes with the student and examines the unit hydroponic garden to check the final flower, vegetable, or fruit product.

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Unit XV—A Resource Unit

HOW CAN I AVOID STIMULANTS AND INJURIOUS DRUGS?

1. OBJECTIVES

a. Both teachers and pupils should obtain a basic background of knowledge concerning the nature of alcohol, kinds, sources, and uses, as well as the history of the alcohol problem itself. They should:

(1) Develop an understanding of the effects of alcohol upon the human body, brain, glands, the general health, and upon the total personality.

(2) Develop an understanding of how the function of parts of the brain affects the function of the corresponding parts of the body. Since alcohol is an anesthetic, it therefore affects the efficiency, the body function, and the coordination.

(3) Understand the value of certain inhibitions—reason, judgment, and self-control, which are released by alcohol anesthesia. This allows unrestrained emotional and physical behavior.

(4) While acquaintance with the various issues involved in the public health is being acquired, realize that alcoholism is a major public health problem.

(5) Develop a sense of pride in possessing vigorous physical and mental health.

They should also:

Realize why people drink, and that drinking is often symptomatic of personal inadequacy.

Understand that individual rights usually terminate wherever and whenever group rights are violated. Learn to lay aside selfish desires for the good of the entire group.

Develop the ability to make critical evaluations and personal choices and assume responsibility for one's own welfare and for the well-being of others.

Acquire the ability to get along well with other people.

Acquire information, habits, and skills that will become a part of a functioning adult.

Create the desire to become a clean and wholesome individual.

Develop a willingness to act upon the finding of scientific facts.

Recognize the foods and drinks that are definitely known to be wholesome and healthful.

Learn to measure the nature and force of advertising methods and the social acceptance of the use of beverages containing alcohol so that they will be able to make intelligent personal decisions.

Learn how social, economic, and political values have been historically confused by the use of, and trade in, beverages containing alcohol.

Create a desire on the part of the pupils to develop personal, family, and group happiness growing out of the useful employment of mind and body.

Develop personal and group responsibility to problems resulting from the use of beverage alcohol.

2. OVERVIEW

a. Historical facts as necessary orientation—Spaulding and Montague's *Alcohol in Human Affairs*

(1) History of drinking

(2) Origin of custom
  - Religious
  - Social
  - Economic
  - Substitute for water

(3) Origin of health instruction in the public schools as a result of insistence upon alcohol and narcotics education

b. The nature of alcohol—kinds, sources, and uses (chemical and commercial)

Ethyl alcohol (found in beverages):
  - A depressant, not a stimulant

c. Effects of alcohol upon the human body

(1) Ingestion vs. digestion (absorption undigested)

Metabolism—liver mostly—and elimination. *(Yale Lay Supplement # 7. Quarterly Journal of Studies on Alcohol)*

(2) Tolerance

Variation of tolerance in persons

No increase of tolerance because a person uses alcohol

Alcohol differs from narcotics: one can increase tolerance to the latter

(3) Alcohol and nutrition

Most diseases resulting from the use of alcohol are nutritional deficiency diseases

The minimum ratio between calories (1600 to one pint of whiskey) and vitamin B_1 of which none is found in alcohol is 1600/2700 or 1.7. *Yale Lay Supplement #8*

(4) Alcohol and its effects on body tissues
Liver
Stomach
Mouth, etc.
Yale Lay Supplement #8. Haggard and Jellinek, *Alcohol Explored,* Chapters 3 and 6

(5) Alcohol and effects on body functions:
Circulation — Temperature
Respiration — Digestion
Coordination. (Haggard and Jellinek, *Alcohol Explored,* Chapter 4.)

(6) Alcohol and effects on disease resistance (Haggard and Jellinek, *Alcohol Explored,* pages 33, 192, 194.)

(7) Alcohol contributing to causes of bodily disorders
Diseased conditions due to malnutrition (beriberi, pellagra)
Diseases contracted through lack of judgment (tuberculosis, venereal diseases)
Alcoholism as an "illness"
Delirium tremens—*Yale Lay Supplement #5*

(8) *Alcohol and Heredity—(Yale Lay Supplement #5)*

(9) *Alcohol and Longevity—(Yale Lay Supplement #6)*

(10) Effect of alcohol on glands, organs, and muscles
Pituitary gland overactive
Stomach, intestines, kidneys, liver, heart, lungs, and blood vessels. (Haggard and Jellinek, *Alcohol Explored*)

d. Effects of alcohol on the brain and nervous system. Reasons for drinking:

(1) Social pressure
Advertising—Tradition—Because others drink

(2) Mistaken ideas of stimulation, relaxation, and medicine
Alcohol belongs to the class of habit-forming drugs that tend to create a craving for increasing amounts of alcohol

(3) Emotional immaturity
Escape from reality or boredom
Escape from discomfort (mental and physical)

e. Effects of drinking *(Yale Lay Supplement #11)*

(1) Higher mental processes
Incapacitated in the reverse order of their development
The drinker becomes intoxicated in mind before he becomes intoxicated in body. This predisposes him to accidents before he is visibly intoxicated
Learning and inhibitions—self-controls
Associative processes, reasoning, and judgment
Memory and caution
Self-criticism, conscience

(2) General and subjective
- False sense of well-being
- False sense of stimulation

(3) Sensory and perceptual
- Vision—depth, breadth, acuity, and color
- Hearing—dulled
- Touch—less sensitive

(4) Psychomotor
- Reaction time
- Endurance
- Sex behavior
- Working efficiency (automobile driving, marksmanship, and school achievement)

f. The psychosomatic stage of drinking

(1) Hang-over stage—A form of illness

(2) Alcoholism and alcohol addiction (stage reached when the person must drink to get over the effects of drinking)
- Many drinkers become addicted (no way of predicting with certainty)
- Reasons for alcohol addiction
  - Psychological
  - Physiological
- Help for the alcoholic
  - Alcoholics Anonymous
  - Other means of therapy

g. Effects of drinking on society

(1) The home and family
- Emotional insecurity, frustration, and turmoil
- Infidelity and divorce
- Delinquency, parental and child
- Lowering of economic standards and poverty

(2) Social calamities and their comparative costs
- Crime—murder, manslaughter, and sex crimes
- Industrial inefficiency
- Traffic and other kinds of accidents

(3) Comparative economic values
- Costs of alcohol vs. costs of education and religion
- Costs of mental and alcoholic institutions
- Costs of liquor advertising—an analysis of its claims
- Increased costs of police protection, jails, etc., resulting from use of alcohol

(4) Social control of drinking
State and local laws
Religious and family controls (ancient and modern)
Personal integration when attained by the individual, renders alcohol unnecessary and personally objectionable

h. The conservation of our human resources

The use of beverages containing alcohol has presented unsolved problems to society at various times and levels

(1) History—the eighteenth and twenty-first amendments
(2) Problems of democracy—state laws concerning alcohol
(3) General social problems

Alcoholism	Crime
Mortality	Disease
Accidents	Economic confusion of values

(4) The nation's drink bill vs. expenditures for schools, churches, hospitals, and charity
(5) Alcohol as a factor in the decline and fall of nations
(6) Alcohol and social reform movements in American history
(7) Alcohol in the reduction of the workingman's efficiency during the Industrial Revolution
(8) The laxity of law enforcement in the 20's

3. SUGGESTED TOPICS FOR INVESTIGATION BY STUDENTS

a. Reasons for drinking involve some knowledge of nearly every aspect of problems of alcohol
b. How American ideas about the effects on health of using alcoholic beverages have changed during the last century and a half
c. Popular fallacies about alcohol which have come down through tradition
d. The bases of advertising of alcoholic beverages
e. Alcoholism as a public health matter
f. Popular attitudes toward the alcoholic today compared with those of half a century ago
g. Is sentencing the alcoholic to jail an adequate form of treatment?
h. Types of people who become alcoholics
i. The costs of alcoholism
j. Traffic accidents resulting from intoxication
k. Does the use of alcohol contribute to accomplishment in the arts and sciences?
l. Alcohol and athletics
m. Total abstinence
n. Is drinking justified for a person who knows when to stop?
o. Systems of licensing and control
p. Why are strict regulations governing conditions of the manufacture and sale of alcoholic beverages necessary?

q. Describe the system of licensing used in Pennsylvania

r. By what methods can popular acceptance and support of effective control measures be encouraged?

s. Public opinion

t. Should there be an agency not sponsored by "wet" and "dry" groups to circulate information and encourage public responsibility about the use of alcoholic beverages?

u. Does the social use of alcoholic beverages make a constructive contribution to society?

4. SUGGESTED CLASSROOM ACTIVITIES

a. Show motion pictures and slides on alcohol

b. Collect newspaper clippings about accidents and deaths due to alcohol

c. Secure information from the local police department on the number of automobile accidents resulting from intoxication

d. Spend at least one class period on advertising materials of the liquor industry and compare them with the news items showing the effect of the use of alcohol

e. Find out the number of drivers' licenses revoked annually in the State because of drinking

f. Collect statistics on the number of automobile accidents resulting from drinking drivers and drunken pedestrians

g. Make newspaper reports on misconduct, such as delinquency and criminality, in which drinking was a factor

h. Discuss such expressions as (a) "If you drink, don't drive; and if you drive, don't drink." (b) "Some people should not drink."

i. Discuss the rules and regulations of railroads, industries, and airplane transport lines with respect to the use of alcoholic beverages by their employes

j. Make posters, charts, and graphs to show healthful foods and drinks

k. Dramatize stories about the effect of the use of alcohol

l. Choose nurses, doctors, vocational home economics teacher, insurance men, and officers of the law to address the class after explaining the aims of the course

m. Conduct suitable discussions of the round-table type about the effects of alcohol, tobacco, and other habit-forming drugs upon the human body

n. Find out from users of tobacco and alcohol what amount of money they spend weekly for tobacco and alcohol

o. List quotations by noted persons relative to the need for abstaining from the use of alcohol, tobacco, and other habit-forming drugs

p. Find out what noted coaches of athletic sports have to say about the use of alcohol by the members of the team

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UNIT XVI

HUMANE EDUCATION

1. OVERVIEW BY TEACHER AND PLANNING WITH PUPILS

A major study of conservation with an outlook to the future of man's well-being as well as that of the creature world should become a motivating influence in cultivating the democratic way of life.

2. LEARNING ACTIVITIES

a. Extinction

A study of the disappearance of species or forms of life from the face of the earth is both enlightening and inspiring. Humane

considerations will take on a new lease of interest. The high school student will profit by special assignment for available information through geological studies. Nature has written these records with imprints of permanence and accuracy more reliable than the more modern recording in books and libraries. Such a study can be followed advantageously by more modern analysis of trends of life showing gradual elimination of species. The humane viewpoint is much enhanced when the depletion of creature life motivates resentment. Such is the virtue of visualizing the destructive aftermath of selfish killing or reckless sportsmanship. We note with serious concern the creatures in modern times that have completely disappeared, and others whose disappearance is threatened. A student can make an interesting report to the class on such assignments as

The disappearance of the heath hen
The passenger pigeon
The threat of extinction of the bison, beaver, egret, bald eagle, and wild turkey (others may be added)

b. Hunting (urban and rural)

(1) Regulating laws and license requirements
(2) The need of restrictions on licenses covering education, identification; skill in using weapons, etc.
(3) Guidance concerning true sportsmanship versus the depravity of the killer
(4) A study of man's interference with the balance of nature and its relationship to licensed hunting versus promiscuous killing

c. Fishing (urban and rural). Approach subject with appeal to humane concern and conservation

(1) Industrial
(2) Destructive practices
(3) Interference with migratory habits
Construction of dams
Hampering salmon spawning
Eels cut off from many of their small stream habitats
(4) Game fish, breeding and stocking
(5) Open season and other game laws

d. Trapping

(1) Steel trap cruelties
(2) Steel trap regulations, Pennsylvania law
(3) More humane leg-gripping traps and their merits
(4) Guillotine or killer traps; possible merit as compared with ordinary steel traps
(5) Deadfall trap—pros and cons
The snare

(6) Large or heavy traps for bear-like creatures and legal limitation of the same; their danger for humans

(7) Live traps, mostly box trap varieties
Freezing and other distress in box traps

(8) Waste, ofttimes involving faulty catch in greater numbers than the number sought

Note: Trapping is rarely kind or humane, but sometimes it is necessary. It is recognized as the outstanding cruelty in the economic relationship between animal and man.

e. Predatory Animals

Some of the predatory creatures have value as fur bearers, for food or for other possible assets, but are known as predatory because they are destructive of other life of possible value. Economically a predatory animal is a creature which destroys more than it saves in human economy.

These creatures give us another slant on a higher level of appreciation. Although they are destructive, they often function very effectively in that intricate law known as THE BALANCE OF NATURE. They may not threaten extinction, but instead may destroy the weakling of the species, thus strengthening the race. Some predatory animals, such as species of owls and hawks, are considered today of economic value.

The teacher and the class may select for unit activity certain creatures with habitat in the community, or some assets or problems related to local animal life.

Foxes	Owls
Snakes	Ferrets
Hawks	

f. Livestock Industry (rural and urban)

(1) Methods of slaughter in the past (major cruelty involved)
(2) Methods of slaughter on farm—past and present
(3) Common methods used today
(4) Improved methods used today
(5) More humane devices and methods in experimental stage
(6) Cash X Captive Bolt Pistol
(7) Electric stunning

g. Livestock Loss Prevention Activities (rural and urban)

(1) Damaged meat—causes and losses
(2) Transportation by train, truck, and on foot

h. Slaughter In Other Fields

(1) Killing sports
(2) Use of air rifles
(3) Archery

(4) Seal killing—methods and problems involved
(5) Poison—where used and where forbidden
(6) Shock by dynamite as a means of killing fish, etc., and problems involved

i. Cruel Sports (rural and urban) Differentiate between humane and inhumane practices

(1) Bull fights
(2) Dog fights
(3) Cock fights
(4) Racing
(5) Live pigeon shoots
(6) Use of weapons

j. History of the Humane Movement (rural and urban)

(1) Societies for the prevention of cruelty (aims, purposes, and methods)
(2) Rescue leagues, dog pounds, and societies for the custody and care of pets, etc.
(3) Humane education and specialized fields of service

k. Controversial Groups (urban)

Somewhere in the layout of the humanitarian guidance, there should be included a definite statement to the effect that—NO LIVING ANIMAL SHALL BE USED IN ANY EXPERIMENT OR DEMONSTRATION INVOLVING PAIN, DISTRESS, OR SUFFERING. A law prohibits such practice in the public schools of Pennsylvania. (Section 1514, Pennsylvania School Laws, 1949.)

3. PUPIL REPORTS AND EXHIBITS

4. EVALUATION

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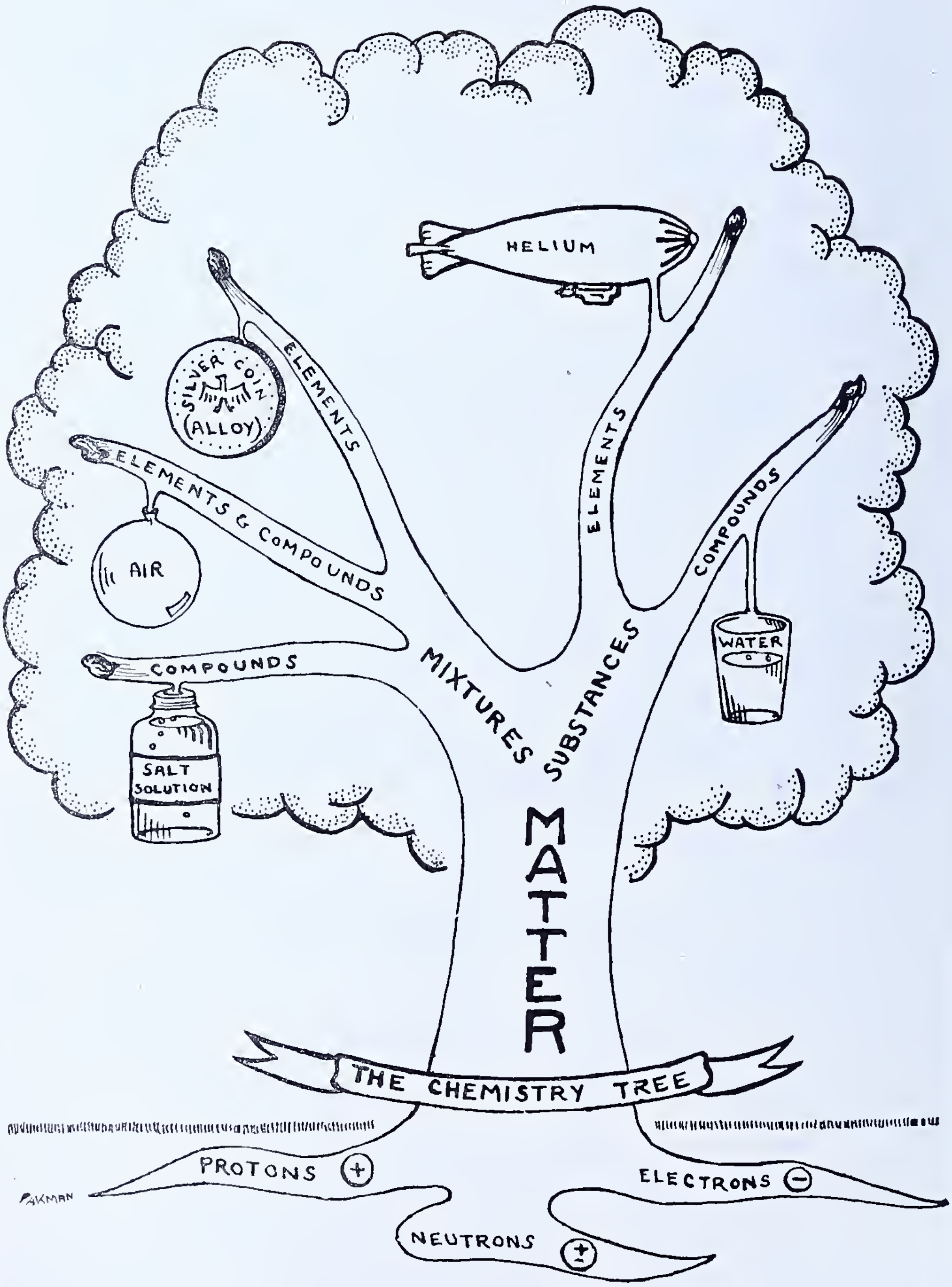
HELIUM
SILVER COIN
(ALLOY)
ELEMENTS
ELEMENTS & COMPOUNDS
AIR
COMPOUNDS
SALT SOLUTION
ELEMENTS
COMPOUNDS
WATER
MIXTURES
SUBSTANCES
MATTER
THE CHEMISTRY TREE
PROTONS +
NEUTRONS ±
ELECTRONS −

CHEMISTRY

Scope

This bulletin uses the *rational* or *functional approach* to secondary school chemistry rather than the historical approach. An attempt has been made to present each new idea in an order which will promote learning.

The rational approach stresses initially the schematic organization of the elements. It begins with the electron, proton, and neutron. From these fundamental particles the atom of the physicist is contructed. Next comes the mastery of the names, symbols, atomic numbers, and configurations of the first twenty elements of the periodic table.

From these twenty elements, the student goes to the simplest compounds, the *binaries*. The formulas for these and the equations for preparing them by direct combination are then presented. The next step is the reverse process, the decomposition of compounds, especially the binaries. More complex compounds are then presented, and after that, come reactions involving single and then double replacement. The concept of energy is stressed constantly.

The advantages of the rational approach may be appreciated by considering a few illustrations of how it operates. At the outset the student learns the correct definitions of such terms as: atomic number, element, isotope, and ion. Very early in the course he learns how to calculate the valence of such ions as *carbonate* and *phosphate*. This he can readily do because he knows the valence of the component parts of such ions. On the foundation of the rational approach it is possible to build an understanding of such concepts as electromotive series, oxidation and reduction (in the electronic sense), dissociation, neutralization, hydrolysis, and electrolysis.

The preparatory unit need not be presented all at one time but should serve as a basis for selecting the points most likely to need attention as the student progresses through the course. All students should take the fundamental units. After these are completed the teacher may exercise considerable freedom in the remainder of the course. He may either use the descriptive and supplementary units or work on life-problem units suited to his learning group. These should provide review and practice in basic principles. The unit on Pennsylvania's Mineral Resources should be given to all groups. College-bound students should complete the Descriptive Units and as many of the Supplementary Units[1] as possible. (See Section on Sequence, page 188.)

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[1] The supplementary Units are taken from "A Minimum Syllabus for a College Course in Chemistry," prepared by the New England Chemistry Teachers Association and published in the January, 1950 issue of the *Journal of Chemical Education.*

The foregoing statements do not imply that the history of chemistry is to be neglected. The point is that the historical approach is not more necessary in chemistry than in any other science. On the other hand, a knowledge of the history of certain chemical developments, such as the explanation of combustion, is most helpful in understanding the operation of the scientific method of problem-solving.

Trends in Chemistry Teaching

The trend in the organization of chemistry courses has been in the planning of units which are related. Most psychologists in education agree that each new principle should be seen as part of an unfolding concept, not as an unrelated bit of information. *At the same time, the bearing which rational organization and principles have upon real life problems should be emphasized.* The study of atomic structure becomes a life problem when the means of preserving human life in an atom bomb explosion are considered.

The following principles should be considered in the planning of a chemistry course.[1]

1. *The course content should help to satisfy real needs of students.*
2. *The course content should be of a proper degree of difficulty, adequate consideration being given in its selection to the maturity level of pupils.*
3. *Economic and social applications should be developed and stressed, particularly those relating to everyday life.*
4. *The content should include a wealth of materials and activities designed for use in developing the abilities and attitudes associated with the scientific method of problem-solving.*
5. *Content that appeals to pupil interest is more likely to influence pupil behavior than that which does not.*

Sequence

The organization must not be looked upon as something to be memorized only. It is a framework which provides direction for the development of understandings, attitudes, and behaviors. To attain these objectives, the following unit sequence is suggested:

[1] *Science Education in American Schools,* the Forty-sixth Yearbook of the National Society for the Study of Education,

PREPARATORY UNIT: What Are the Tools and Mathematics of the Chemist?
UNIT I: What Are Electrons, Protons, and Neutrons?
UNIT II: What Are Elements and Isotopes?
UNIT III: What Is the Nature of Each of the First Twenty Elements?
UNIT IV: How Are Compounds Formed from Elements?
UNIT V: How Do Pure Substances and Mixtures Differ?
UNIT VI: How Are Complex Compounds Made Up?
UNIT VII: How Can Compounds Be Decomposed?
UNIT VIII: How Do Metals Differ in Their Activity?
UNIT IX: How Do Ions Work for Man?
UNIT X: Gases at Work
UNITS XI-XVII: Descriptive Chemistry Units—See page 212
UNITS XVIII-XXVI: Supplementary Units—See page 212
UNIT XXVII: Pennsylvania's Mineral Resources
UNIT XXVIII: Chemical Equations and Computations
UNIT XXIX: What Shall We Eat?—A Life Problem Unit

Introducing Units

Pupil-teacher planning is a component of effective functional teaching. (See *Evaluative Criteria,* The Cooperative Study of Secondary School Standards, Washington, D. C.) The introduction of units may take the form of:

1. An overview by the teacher
2. Group discussion on:
   a. What do we know now?
   b. What do we need to find out?
   c. What work plan shall we use?

Such planning, in accordance with democratic procedure, awakens the concern and participation of students. Frequently problems and activities are suggested which add greatly to initial mastery and to retention. In addition, students acquire practice in planning, which is an essential life activity. Samples of student self-appraisal check lists are included. Others may readily be constructed by the teacher.

The unit titles and outlines are suggestive and flexible. Variation in topics, objectives, and activities will be desirable as circumstances vary. Units may be extended to meet the specific problems of pupils and of communities. The study of chemistry provides a rich store of material for considering the critical human problems of health, work, home and family living, the interdependence of man, the use of leisure, consumer judgment, and the like. Unless these needed attitudes for good citizenship are approached concurrently, the best of knowledge has little profit.

Evaluation

With the rational approach to chemistry there must be frequent tests on the mechanics of atomic configurations, formulas, and equations. At least one test per unit should be given. In all probability some tests will have to be repeated. Unless the student gets each step as he goes, there is no merit in this system. Problems based on the weight relations of the equation may also be introduced fairly early. Where there is difficulty in solving such problems, a check should be made of the mathematics involved and an appropriate review given.[1]

The ideal evaluation of any subject is of course its effect on the behavior of the student. If he learns the dangers of carbon monoxide, he will be concerned that no one runs an automobile engine in a closed garage. The alert teacher should be able to discover and teach for such behaviors on the part of his students. Means for such evaluation are suggested in Chapter IV on "Evaluation."

Many students voluntarily bring to class clippings from newspapers and periodicals. This practice should be encouraged. It is helpful in promoting and evaluating the student's interest in the subject. If he selects clippings wisely and writes a short paragraph or reports orally, explaining the application of the principles, the practice is a good teaching aid.

Comprehensive evaluation involves the student in the self-evaluation of his own learning. Practice in this ability is essential for self-motivation. The types of self-appraisal check lists on Units I and II are suggested for this purpose.[2]

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[1] For evaluating the accomplishments of the student at the end of the course there is probably nothing better than the "Cooperative Chemistry Test" published by Educational Testing Service, 15 Amsterdam Avenue, New York 23, N. Y. This test is available in a number of forms and presents considerable data on the national norms of the test. Administration of the same test to the same students six months or a year later is necessary for the teacher to evaluate his teaching on the basis of retention.

[2] Such student participation in evaluation is recognized in D-15 of the 1950 Edition of the *Evaluative Criteria*, Cooperative Study of Secondary School Standards, Washington, D. C.

PREPARATORY UNIT

WHAT ARE THE TOOLS AND MATHEMATICS OF THE CHEMIST?

Content	*Objectives*	*Learning Experiences*
1. Units of the metric system a. Dollar b. Meter c. Liter d. Gram e. Degree centigrade f. Calorie g. Karat	1. To acquire skill in measuring the metric way 2. To understand the advantages of the metric system 3. To develop skill in using various tools of measuring 4. To review the mathematics necessary in understanding chemistry	1. *Overview by teacher with group planning* 2. *References* a. Look up metric tables of measurement in dictionary or other reference books b. Find the names and values of three units of measurement used by the ancients
2. Tools of measurement a. Ruler b. Graduated cylinder c. Balance d. Thermometer e. Barometer	5. To learn how to handle bottle stoppers 6. To learn how to pour a liquid from a large to a small container 7. To develop proper habits in connection with the use of matches, Bunsen burners, and other heating devices	3. *Projects* a. Make a 15 cm. ruler out of cardboard b. Make a model liter out of cardboard. Look at a butter box to see one way of folding
3. Tools involving the use of energy a. The match b. Bunsen burner c. Electric current d. Magnet	8. To learn about jobs and professions 9. Other objectives suggested by pupils	c. Make a model milliliter out of soap d. Make a thermometer scale marking each ten degrees Centigrade from 0° to 100° and the Fahrenheit equivalents
4. Relation between the value of silver coins in cents and their weight in grams		4. *Laboratory* a. Measure the lengths of common objects such as pencils, books, doors, and tables in metric units b. Weigh common objects such as keys, coins, and pencils in metric units

PREPARATORY UNIT—Continued

WHAT ARE THE TOOLS AND MATHEMATICS OF THE CHEMIST?—Continued

Content	*Objectives*	*Learning Experiences*
5. Review of arithmetic and algebra a. Decimals b. Percentage c. Ratio and proportion d. Lowest common multiple e. Solving for x in an equation		c. Determine the volume of a test tube, beaker, or bottle in ml. d. Determine the density of water in grams per ml. e. Determine whether sample letters or packages have sufficient postage
6. Other content suggested by pupils		5. *Problems* Work out sample problems which illustrate the mathematical principles listed in column one 6. *Other activities suggested by pupils* 7. *Evaluation:* See Chapter IV and material in this section on evaluation on page 190.

Student Self-Appraisal Check List for Preparatory Unit—What Are the Tools and Mathematics of the Chemist?

Useful knowledge	*Yes*	*D.*[1]	*No*
a. Can you describe the work of the Bureau of Standards?			
b. Can you explain why an average of several precise measurements is better than one measurement?			
c. Can you discuss what is meant by "limits of tolerance"?			
d. Can you describe the advantages of the metric system?			
e. Do you know what the Latin word *scio* means and how this is related to science?			
f. Can you describe some time-saving devices which are in daily use?			
g. Can you name the measuring instruments which are used by a surveyor? A carpenter? A doctor?			
h. Do you know what is the purpose of time and motion study in industry?			
i. Can you discuss how time and motion study might be related to the layout of a kitchen? To making a bed?			
j. Can you explain the relationship of measurements to thrift?			

[1] Doubtful.

Vocabulary

Can you explain and use the following words or terms?

	Yes	*D.*	*No*
a. barometer			
b. calorie			
c. candle-power			
d. centigrade			
e. gram			
f. gravity			
g. liter			
h. mass production			
i. micrometer			
j. precision			

Principles and Laws

Can you state four ways in which measurement helps any of the following?

Getting to school on time, driving an automobile, fishing, buying food, handling money, taking a chance.

1. __________
2. __________
3. __________
4. __________

Daily activities and phenomena

Can you list four other daily activities which illustrate any of the following?

Precision measurements, mass production, averaging measurements, making time and motion studies, limits of tolerance

1. __________
2. __________
3. __________
4. __________

Demonstration and Experiment

Can you prove or show:	*Yes*	*D.*	*No*
a. How many centimeters there are in an inch?			
b. That a liter is larger than a dry quart?			
c. How to read an electric meter? A gas meter?			
d. How to measure out one ounce when you have: a chemical balance, 16 ounces of sand and 2 pieces of filter paper?			

When the sun is shining, can you find north by using the face of a watch?

What else did you learn in this unit?

What help did you give to what your class did?

UNIT I

WHAT ARE ELECTRONS, PROTONS, AND NEUTRONS?

Content	*Objectives*	*Learning Experiences*
1. The nature and definition of these three elementary particles of matter: a. What is matter? b. What is energy? c. States of matter?	1. To become familiar with the evidence for believing in the existence of these particles	1. *Preview:* Write a paragraph stating what you already know about these particles and what you need to find out Read about: Democritus, Rutherford Franklin, Lawrence Thomson Talk by an electronics engineer
2. Forms and transformations of energy	2. To learn that all matter is composed of these particles	2. *Projects* a. Make a list of all appliances and machines you know of which make use of electricity
3. What precautions should be taken during a thunderstorm?	3. To understand the purpose of atom smashers such as the cyclotron	b. Visit an institution which has an atom smasher. Write a report on it
4. What is an electric current?	4. To learn how to use electrons Precautions in the use of common household electrical appliances	c. Perform a simple experiment that illustrates static electricity. Describe it
5. Why do we sometimes get a shock after walking over a heavy carpet and then touching a piece of metal?	5. To learn the symbols of these particles	d. Report on action in case of an atomic bomb attack
6. Express the diameter of an electron in centimeters.	6. To learn that other subatomic particles exist which are not of direct interest in beginning chemistry	e. In a tabular outline show how the three states of matter are related in regards to definite volume and definite shape
7. Other content suggested by pupils	7. To learn in what three ways an atomic bomb kills people	f. In a tabular outline show how the three fundamental particles are related in regards to mass and charge
	8. To find out how to take immediate precautions in case of an atomic bomb explosion	g. Find additional projects and report on them
	9. To learn about job opportunities, requirements, and pay in the field of electronics	h. Talk by a radio man
	10. Other objectives suggested by pupils	

Learning Experiences

3. *Demonstration and Laboratory*
   a. Simple static effects
   b. Electroscope
   c. Neon tube
   d. Electric eye
   e. Geiger counter
   f. Cathode ray tube and magnet
4. *Continuous study of text and references*
5. *Other activities suggested by pupils*
6. *Evaluation:*
   a. Unit test
   b. Group discussion:
      (1) What worth-while projects have been worked out?
      (2) What student interests have been developed which may be expected to continue?
7. *Direct teaching and drill where needed*

CHART HELPS STUDY OF THE ATOM

Student Self-Appraisal Check List for Unit I—What Are Electrons, Protons, and Neutrons?

1. *Useful Knowledge*

	Yes	D.	No
a. Can you explain what matter is?			
b. Do you know in what physical states matter exists?			
c. Can you explain the properties of matter?			
d. Do you know what forces hold solids together?			
e. Can you explain the difference between ice, water, and steam?			
f. Do you know how sap goes up a tree?			
g. Do you know why soap bubbles are spherical?			
h. Do you know whether a needle will float in water?			
i. Do you know what a molecule is?			

2. *Vocabulary*

Can you explain and use the following words or terms?

	Yes	D.	No
a. absolute temperature			
b. capillarity			
c. dew point			
d. elasticity			
e. energy			
f. hypothesis			
g. solubility			
h. osmosis			
i. space			
j. surface tension			

3. *Principles and Laws*

Can you name six principles or laws which explain any of the following?

Popping corn, starching clothes, shooting a slingshot, automobile blowouts, refrigeration, ink blotting, filtering water

1. ______ 4. ______
2. ______ 5. ______
3. ______ 6. ______

4. *Daily Activities and Phenomena*

Can you name six everyday activities or phenomena which illustrate the following?

surface tension, capillarity, adhesion, expansion and contraction, osmosis

1. ______ 4. ______
2. ______ 5. ______
3. ______ 6. ______

	Yes	D.	No
5. Can you explain how dew "falls"?			

6. What else have you learned in this unit?

7. What help did you give to the work of your class?

UNIT II

WHAT ARE ELEMENTS AND ISOTOPES?

Content	*Objectives*	*Learning Experiences*
1. Configurations of the lightest three elements and their isotopes a. Hydrogen b. Deuterium c. Helium d. Lithium e. Heavy Lithium 2. Definitions of a. Atomic number b. Atomic weight c. Neutron d. Nucleus e. Element f. Isotope g. Deuterium h. Alpha particle 3. Solar and stellar energy 4. Transmutation 5. Einstein Equation 6. The words *inseparable atom* a misnomer 7. The atom as a miniature solar system 8. Explain the analogy between the average weight of the individuals in a litter of puppies and the atomic weight of an element. 9. In 1,000 atoms of lithium, 83 have a mass of 6 and the others of 7. Compute the atomic weight of lithium. 10. Other content suggested by pupils	1. To learn to represent an atom by means of a configuration 2. To understand that the difference in the composition of atoms of different elements is in the number of electrons, protons, and neutrons they contain 3. To learn that the mass of the atom is nearly all in the nucleus 4. To learn that the number of neutrons in an atom is the difference between the atomic weight and the atomic number 5. To learn that the number of protons in an atom is the same as the number of planetary electrons 6. To explain the difference between chemical energy and nuclear energy 7. Other objectives suggested by pupils	1. *Overview by teacher* Group planning 2. *Reading.* Look up: Moseley Aston Urey Bethe 3. *Student Projects* a. Outline the steps in Bethe's theory for the origin of solar energy b. In parallel columns outline the configuration, composition, symbol, charge, and mass of each atom of the lightest three elements 4. *Demonstration and Laboratory* a. Demonstrate the effect of helium on the voice b. By means of the Geiger counter show the presence of radioactivity in suitable selected materials c. Make models of these light atoms 5. *Continuous study of text and references* 6. Show films on the uses of radioactive isotopes in medicine and research 7. *Other activities suggested by pupils* 8. *Evaluation:* (See page 190) 9. *Direct teaching and drill* where need is shown by unit test

UNIT III

WHAT IS THE NATURE OF EACH OF THE FIRST TWENTY ELEMENTS? (See page 200)

Content	*Objectives*	*Learning Experiences*
1. What are the configurations of the first twenty elements according to atomic number? 2. What are the covalence and the molecular formulas of the gaseous elements a. Oxygen O_2 b. Hydrogen H_2 c. Nitrogen N_2 d. Fluorine F_2 e. Chlorine Cl_2 3. Electrovalence and electron orbits: K, L, M, and N 4. What are the outstanding facts concerning the nature and uses of these elements? Make a list 5. Four types of elements and illustrations of them a. Metal — Sodium b. Nonmetal — Chlorine c. Amphoteric — Carbon d. Inert — Neon 6. Configurations for the molecules of the gaseous elements listed above	1. To learn the names, symbols, and atomic numbers of the first twenty elements. (*Note:* This information is the key to all that follows and must be mastered before any further progress can be made.) 2. To learn that the electrovalence of an element is determined by the number of electrons the atom can borrow or lend 3. To learn the distinctive nature of the four types of elements 4. To get a preliminary view of the periodic arrangement of the atoms 5. To learn some uses of these elements 6. To understand how the uses of chemical substances are related to their properties 7. Other objectives suggested by pupils	1. *Overview by teacher* Group planning 2. *Student Projects* a. Make a spark coil or salvage one from an old automobile. This will be very useful in many experiments b. Find out which of these elements were known to ancient man. List those mentioned in the Bible c. Make a collection of as many of them as can be obtained d. Outline the configurations of the first twenty elements according to their order in the periodic table. In each one indicate the symbol and the atomic number e. Make an outline in tabular form, of the four types of elements indicating the atomic weight, atomic number, number of protons, configuration, valence, electron behavior, and type of element f. Talk to class by a chemist 3. *Demonstration and Laboratory* a. A collection of as many of these elements as can be obtained should be made up and mounted on an exhibit board

Content	Objectives	Learning Experiences
7. Key to Physical Properties S—State C—Color O—Odor L—Liquid relations D—Density S—Solubility		b. A film on coal, sulphur, or aluminum may be shown 4. *Continuous text and references study* 5. *Other activities suggested by pupils* 6. *Evaluation:* (See page 190) 7. *Direct teaching and drill where need is shown by unit test*
8. Which of these first twenty elements are mined or produced in Pennsylvania?		
9. Other content suggested by pupils		

Chart of First Twenty Elements

+1 −7	+2 −6	+3 −5	+4 −4	+5 −3	+6 −2	+7 −1	0
1 Hydrogen H							2 Helium He
3 Lithium Li	4 Beryllium Be	5 Boron B	6 Carbon C	7 Nitrogen N	8 Oxygen O	9 Fluorine F	10 Neon Ne
11 Sodium Na	12 Magnesium Mg	13 Aluminum Al	14 Silicon Si	15 Phosphorus P	16 Sulphur S	17 Chlorine Cl	18 Argon A
19 Potassium K	20 Calcium Ca						

NOTE: The numbers at the head of the columns are the valence numbers of the elements in the column.

Four Types of Elements

Example	*Sodium—Na*	*Chlorine—Cl*	*Carbon—C*	*Neon—Ne*
Atomic Weight	23	35	12	20
Atomic Number	11	17	6	10
Neutrons in nucleus	12	18	6	10
Configuration	11p 12n 11e 2-8-1	17p 18n 17e 2-8-7	6p 6n 6e 2-4	10p 10n 10e 2-8
Valence Number	+1	-1	±4	0
Electron Behavior	Lends	Borrows	Either	Neither
Type of Element	Metal	Nonmetal	Amphoteric	Inert
Compound with Hydrogen	—	HCl	H_4C	—
Compound with Oxygen	Na_2O	—	CO_2	—

NOTE: *p* represents proton; *n* neutron; and *e* electron.

UNIT IV

HOW ARE COMPOUNDS FORMED FROM ELEMENTS?

Content	*Objectives*	*Learning Experiences*
1. Formation of binary compounds from first twenty elements only	1. To learn the methods by which binary compounds are formed	1. *Overview by teacher* Group planning
2. Direct combination chemical changes	2. To learn to write the formulas of all possible compounds formed from the first twenty elements	2. *Demonstration and Laboratory* Exhibit specimens of available samples of these compounds
3. Distinction between chemical and physical changes	3. To learn how to recognize and identify the more important of these compounds	3. *Prepare and discuss* a. Magnesium oxide b. Diphosphorus pentoxide c. Carbon dioxide d. Sodium chloride e. Calcium sulphide f. Others
4. Questions on chemical changes a. Does it burn? b. Does it support combustion? c. Does it react with water? d. Does it react with acids?	4. To learn how to name binary compounds	4. *Student Projects* a. Identify and collect representative specimens of these compounds, such as: (1) Calcium difluoride (2) Silicon dioxide (3) Carbon disulphide (4) Silicon carbide (5) Dialuminum trioxide b. Visit a museum having a mineral exhibit in order to find other binaries of the first twenty elements
5. Nomenclature of binary compounds[1]	5. To learn how to write equations for the formation of binary compounds	5. *Continuous study in text and reference books*
6. Mechanics of handling binary compounds a. Writing formulas b. Formula (molecular) weight c. Writing equation d. Weight problems based on the equation	6. To learn how to work problems based on these equations	6. *Other activities suggested by pupils*
7. Law of Definite Proportions	7. Other objectives suggested by pupils	7. *Evaluation:* (See p. 190)
8. How many grams of aluminum oxide can be formed by the complete oxidation of 54 g. of pure aluminum?		8. *Direct teaching and drill* where need is shown by unit test
9. Other content suggested by pupils		

[1] System of nomenclature to be followed is that recommended by the Committee of the International Union of Chemistry, which was published in the *Journal of the American Chemical Society,* 63, 889 (1941). "Rules for Naming Inorganic Compounds," 10¢, *Chemical Abstracts.* Ohio State University, Columbus 10, Ohio.

Unit V

HOW DO PURE SUBSTANCES AND MIXTURES DIFFER?

Content	*Objectives*	*Learning Experiences*
1. Every variety of matter is either a pure substance or a mixture	1. To understand the nature of solutions and the distinction between true solutions and near-solutions	1. *Overview by teacher* Group planning
2. The components of a solution are pure substances and the solution is a mixture of two or more pure substances	2. To learn how water is purified	2. *Student projects* a. When the opportunity presents itself, collect some freshly fallen snow and melt it in a clean vessel. Compare samples collected at the beginning and the end of a storm
3. Definition of solution	3. To learn how to test water for purity	b. Make a list of solutions found in the home or elsewhere. Select those which have some practical use
4. Solute and solvent	4. To acquire skill in handling reagent bottles and their stoppers	c. Make a rain gauge and record daily precipitation for a period of a month or more
5. Classification of solutions a. Dilute and concentrated b. Saturated and unsaturated	5. To acquire skill in pouring liquids from large into small containers safely	d. Determine dew point
6. Solutions of solids, gases, and liquids	6. To learn how to express the concentration of a solution	e. Make and use a wet-dry bulb hygrometer
7. Solubility and temperature	7. To learn the nature of vapors	f. Visit a weather bureau
8. Solubility and pressure	8. To learn the true meaning of boiling point	3. *Demonstration and Laboratory* a. Experiments on: (1) Distillation (2) Solubility (3) Filtration (4) Process of solution (5) Deliquescence (6) Emulsion making
9. Properties of water, physical and chemical	9. To appreciate the importance of water as a natural resource	b. Demonstration of solid alcohol
10. Purification of water: sedimentation, filtration, and distillation	10. To understand how everyone can help to preserve water resources	c. Demonstration of the making of a molar solution using a volumetric flask
11. Potable water	11. Other objectives suggested by pupils	
12. Water vapor and boiling point		
13. Evaporation-precipitation a dynamic equilibrium		

Content	*Objectives*	*Learning Experiences*
14. Process of making a solution		4. *Continuous study in text and reference books*
15. Mole and molar solution		5. *Other activities suggested by pupils*
16. Near-solutions: suspensions, emulsions, and colloids		6. *Evaluation:* (See p. 190)
17. Difference between vapor and gas Find some illustrations of vapor		7. *Direct teaching and drill* where need is shown by unit test
18. Other content suggested by pupils		

UNIT VI

HOW ARE COMPLEX COMPOUNDS MADE UP? (See page 206)

Content	*Objectives*	*Learning Experiences*
1. Common ions and radicals derived from the first twenty elements. The chief ones are: NH_4 SiO_3 HCO_3 SiF_6 HSO_4 SO_4 NO_3 B_4O_7 ClO_4 S_2O_3 OH BO_3 CO_3 PO_4 Writing formulas and nomenclature of ternary and quaternary compounds	1. To learn the derivation of the more common ions and radicals 2. To derive the valence of these 3. To learn to write the formulas of ternary and quaternary compounds 4. To learn how to determine the percentage composition of a given compound	1. *Overview by teacher* Group planning 2. *Study the hydrates available* in the laboratory and in the mineral department of a museum 3. *Demonstration and Laboratory* a. Exhibit specimens of (1) Calcium carbonate (2) Sodium carbonate (3) Sodium hydrogen carbonate (4) Magnesium hydroxide
2. Compound-compounds a. Resolution of empirical formula of complex compounds into simple formulas. For instance, feldspar ($KAlSi_3O_8$) becomes $\frac{K_2O,\ Al_2O_3,\ 6SiO_2}{2}$ b. Treat formulas for magnetite, alums, and bleaching powder in the same manner	5. To learn how to find the simplest formula of a compound from the percentage composition 6. To learn the test for a hydrate 7. To learn how to name hydrates 8. Other objectives suggested by pupils	b. Experiments (1) Testing for a hydrate (2) Determination of the water of hydration and its percentage in a common hydrate (3) Grow crystals of alums of different kinds (4) Make plaster of Paris out of gypsum (5) Make casts out of plaster of Paris
3. Hydrates a. Nomenclature using Greek prefix to designate the correct quantity of water b. Percentage composition from formula c. Formula from percentage composition		4. *Special Class Project* Make improvised conductivity kits from available materials, such as rubber stoppers, pencil leads (electrodes) and covered wire 5. *Directed study in text and reference books*

Content	*Objectives*	*Learning Experiences*
4. Dissociation, Ionization, Conductivity, Electrolytes, and Nonelectrolytes		6. *Other activities suggested by pupils*
5. Select a ternary compound and from its formula compute its percentage composition. Then from the percentage composition compute the formula		7. *Evaluation:* (See p. 190)
6. Law of Multiple Proportions		8. *Direct teaching and drill* where need is shown by unit test
7. Other content suggested by pupils		

FIRST TWENTY-ELEMENT IONS

Name	Ion Formula	Components				Charge
		Positive		Negative		
Ammonium	NH_4	H_4	+4	N	−3	+1
Bicarbonate	HCO_3	H C	+1 +4	O_3	−6	−1
Bisulphate	HSO_4	H S	+1 +6	O_4	−8	−1
Nitrate	NO_3	N	+5	O_3	−6	−1
Perchlorate	ClO_4	Cl	+7	O_4	−8	−1
Hydroxide	OH	H	+1	O	−2	−1
Carbonate	CO_3	C	+4	O_3	−6	−2
Silicate	SiO_3	Si	+4	O_3	−6	−2
Sulphate	SO_4	S	+6	O_4	−8	−2
Tetraborate	B_4O_7	B_4	+12	O_7	−14	−2
Thiosulphate	S_2O_3	S	+6	S O_3	−2 −6	−2
Silicofluoride	SiF_6	Si	+4	F_6	−6	−2
Borate	BO_3	B	+3	O_3	−6	−3
Phosphate	PO_4	P	+5	O_4	−8	−3

UNIT VII

HOW CAN COMPOUNDS BE DECOMPOSED?

Content	*Objectives*	*Learning Experiences*
1. Methods of decomposing compounds a. By *electricity:* water, salt solutions, and melted salts b. By *heat:* mercuric oxide; volatile compounds such as carbonic acid and ammonium carbonate c. By *catalysis:* hydrogen peroxide d. By *heat and catalysis:* potassium chlorate	1. To learn several methods of decomposing compounds	1. *Overview by teacher* Group planning
2. Preparation of oxygen in quantity from potassium chlorate	2. To learn how to prepare oxygen in quantity	2. *Demonstration and Laboratory* a. Preparation of oxygen from potassium chlorate: from HgO; H_2O_2 and water (1) Dust explosions (2) Catalysis (3) Kindling temperature Davy safety lamp (4) Spontaneous combustion b. Appropriate film and filmstrips
3. Preparation of oxygen by three other methods (demonstration)	3. To learn the mechanics of collecting a gas by the displacement of water and to acquire skill in so doing	3. *Student Projects* a. Improvise an apparatus for the electrolysis of water. Use ordinary laboratory equipment b. Prepare oxygen at home from hydrogen peroxide; manganese dioxide from an old dry cell may be used as the catalyst
4. Preparation of hydrogen (Briefly by electrolysis of water)	4. To learn how to decompose water by electrolysis	4. *Other projects suggested by students*
5. Properties of oxygen, both physical and chemical	5. To learn how to write equations for the decomposition of a pure substance	5. *Directed study in text and reference books*
6. Equations for above illustrations and others to be selected	6. To learn how to test the density of a gas relative to air by the upsideup-upsidedown method	6. *Evaluation:* (See p. 190)
7. Test for density of a gas relative to air	7. To learn how to prevent spontaneous combustion in the home, shop, store, and on the farm	7. *Direct teaching and drill* where need is shown by unit test
8. Law of multiple proportions (Meaning of *multiple*)	8. To learn the law of multiple proportions and its significance	
9. Illustrations such as water and hydrogen peroxide	9. Other objectives suggested by pupils	
10. Try to find at least two other methods of decomposing compounds and state an illustration of each		
11. Why does a heap of freshly mown lawn grass get very hot in summer?		
12. Other content suggested by pupils		

Unit VIII
HOW DO METALS DIFFER IN THEIR ACTIVITY?

Content

1. Chemical changes involving single replacement:
   a. Electromotive Series (Replacement series)
   b. Oxidation—increase in valency
   c. Reduction—decrease in valency
   d. Emphasis on the action of aluminum, zinc, copper, iron on solutions of various metallic salts
   e. Preparation of hydrogen by the action of metals (lithium, sodium, potassium, and calcium) on water
   f. Preparation of hydrogen (in quantity) by action of metals (zinc, aluminum, magnesium, and iron) on acids (hydrochloric and sulphuric)
   g. Dry reduction of copper oxide by hydrogen
2. Diffusion of hydrogen
3. Equations for reactions indicated above
4. The silver nitrate test for counterfeit "silver" coins
5. Incandescent substances produce colored lights
6. Use of the spectroscope
7. What is an amalgam?
8. What is the total cost of corrosion in the United States in a year?
9. Other content suggested by pupils

Objectives

1. To learn how and why certain metals replace other metals from solutions of their salts
2. To learn why certain metals occur free in nature while others never do
3. To learn why certain metallic oxides are more readily reduced than others
4. To learn the approximate order of activity of the more commonly used metals
5. To learn how to collect hydrogen in quantity by the action of metals on acids
6. To learn the physical and chemical properties and the uses of hydrogen
7. To learn how two gases of different density can be separated by diffusion
8. To learn how to make flame tests
9. To learn the principle of the spectroscope
10. To learn the precautions which should be taken in working around explosive gases
11. To learn the proper use of cylinders of compressed gases
12. Other objectives suggested by pupils

Learning Experiences

1. *Overview by teacher*
   Group planning
2. *Student Projects*
   a. Find out why the copper ridge roll on the roof of a building turns green after exposure to the atmosphere for a few years
   b. Find out how machinists etch metals
3. *Demonstration and Laboratory*
   a. Observation of action of metals on salt solutions. Emphasis on the action of zinc, copper, and iron on acids and on solutions of silver nitrate, mercurous nitrate, lead acetate, copper sulphate, and iron chloride
   b. Preparation of hydrogen in quantity by action of zinc or iron on either hydrochloric or sulphuric acid
   c. Flame tests of alkali metals with and without a cobalt glass filter
4. *Other activities suggested by pupils*
5. *Continuous use of references*
6. *Evaluation:* (See p. 190)
7. *Direct teaching and drill* where need is shown by unit tests

UNIT IX

HOW DO IONS WORK FOR MAN?

Content	*Objectives*	*Learning Experiences*
1. Chemical changes involving double replacement 2. Neutralization 3. Hydrolysis 4. The pH Scale. The pH value of common substances and materials such as baking soda, water, bread, soft drinks, sea water 5. Common indicators and their use 6. Nomenclature of acids and their corresponding salts a. Binary acids b. Oxygen acids c. Chlorine acids 7. Making volatile acids a. Hydrochloric acid b. Nitric acid 8. Why reactions go to an end a. Precipitation b. Volatility c. Neutralization 9. Rules of solubility 10. Reversible reactions 11. Law of mass action	1. To learn how acids and bases neutralize each other 2. To learn why not all salts are neutral 3. To learn the meaning of the pH Scale and the approximate pH values of common materials 4. To learn how to write equations involving double replacement 5. To learn why reactions come to an end 6. To learn the names and formulas of five common acids and five common bases 7. To learn the color ranges and pH ranges of a few indicators such as brom thymol blue and brom cresol purple 8. To learn how to test the soil of your garden or lawn for acidity 9. To learn what vocations involve use of ions 10. To learn the test for the chloride ion and the sulphate ion 11. Other objectives suggested by pupils	1. *Overview by teacher* Group planning 2. *Student Projects* a. Make some indicator solution at home (1) Purple cabbage extract (2) Phenolphthalein from phenolphthalein tablets or gum and rubbing alcohol b. Test for pH of common substances c. Test the acidity of your soil d. Silver plating 3. *Demonstration and Laboratory* a. Study properties of common acids and bases b. Prepare a few salts, such as sodium chloride and potassium sulphate c. Prepare insoluble salts, such as silver chloride, silver chromate, lead chromate d. Prepare a few gases, such as carbon dioxide, sulphur dioxide, and hydrogen sulphide e. Electrolytic demonstration of neutralization with barium hydroxide and sulphuric acid

Unit IX—Continued

HOW DO IONS WORK FOR MAN?—Continued

Content	*Objectives*	*Learning Experiences*
12. Common ion tests a. Chloride ion b. Sulphate ion 13. Preparation of chlorine 14. How to distinguish between hydrochloric and nitric acid when they are contained in two unlabeled bottles 15. How to distinguish between sulphuric and hydrochloric acid 16. Other content suggested by pupils		f. The hydrolysis of common salts (1) Sodium chloride (2) Copper sulphate (3) Sodium tetraborate (4) Potassium nitrate (5) Aluminum sulphate (6) Sodium carbonate 4. *Directed study in text and reference books* 5. *Other activities suggested by pupils* 6. *Evaluation:* (See p. 190) 7. *Direct teaching and drill* where need is shown by unit test

UNIT X

GASES AT WORK

Content	*Objectives*	*Learning Experiences*
1. Kinetic theory of matter a. Compression—a heating process b. Expansion—a cooling process 2. Law of Boyle: Illustrated by the stratosphere balloon of 1935 3. Law of Charles: Illustrated by the explosion of a steam boiler 4. Changing volume at observed conditions to volume at standard conditions a. Correction for differences of level and for aqueous tension b. Changing from centigrade to absolute 5. Laws of Avogadro and Gay-Lussac 6. Relation between the gram molecular weight of a gas and the weight of one liter of it 7. Proof for the diatomic formula of elementary gases, such as oxygen, hydrogen, fluorine, nitrogen, and chlorine 8. The analogy between the volumes of reacting gases and the trading of postage stamps of different denominations 9. The aerosol insecticidal bomb 10. Assuming air to be $\frac{4}{5}$ nitrogen and $\frac{1}{5}$ oxygen, calculate the weight of one liter of air 11. Other content suggested by pupils	1. Learn the laws for gases 2. To understand how the gas laws apply to problems of daily living 3. To learn how to calculate the density and specific gravity of any gas from its formula 4. To develop skill in measuring the volumes, pressure, and temperatures of a gas 5. To learn what precautions should be taken in handling all compressed gases 6. To understand the use of the aerosol bomb around the home 7. To learn how to make a mercurial barometer 8. To learn the precaution to take in handling mercury 9. To learn what vocations involve the use of gases 10. Other objectives suggested by pupils	1. *Overview by teacher* *Group planning* 2. *Student Projects* a. Collapse a one-gallon tin can in the laboratory b. Make a list of ten simple experiments you can do to prove that air exerts pressure c. Keep a record of atmospheric pressures for one month as published on the daily weather map of your nearest weather station 3. *Demonstration and Laboratory* a. Demonstrate how a barometer is made b. Perform one of these experiments—Determine the atomic weight of magnesium or determine the molecular weight of oxygen c. Exhibit an aneroid barometer and other instruments for measuring weather conditions 4. *Other activities suggested by pupils* 5. *Continuous use of references* 6. *Evaluation:* (See p. 190) 7. *Direct teaching and drill* where need is shown by unit test

Units XI–XVII

DESCRIPTIVE CHEMISTRY UNITS

The main objective in these units is to learn the properties, preparation, reactions, and practical applications of the substances listed. The learning experience will consist mainly of textbook study and doing or observing the experiments involved.

Unit XI: Sulphur, sulphur dioxide, dihydrogen sulphide, sulphuric acid, and sulphates

Unit XII: Nitrogen, the atmosphere, nitrogen oxides, ammonia, nitric acid, and nitrates

Unit XIII: Carbon, carbon monoxide, carbon dioxide, methane, methyl alcohol, and ethyl alcohol

Unit XIV: The halogen family, common halides, and related acids

Unit XV: Sodium, common sodium compounds, preparation of the pure metal, occurrence, and simple reactions

Unit XVI: Aluminum (treatment similar to sodium)

Unit XVII: Iron (treatment similar to sodium)

Units XVIII–XXVI

SUPPLEMENTARY UNITS

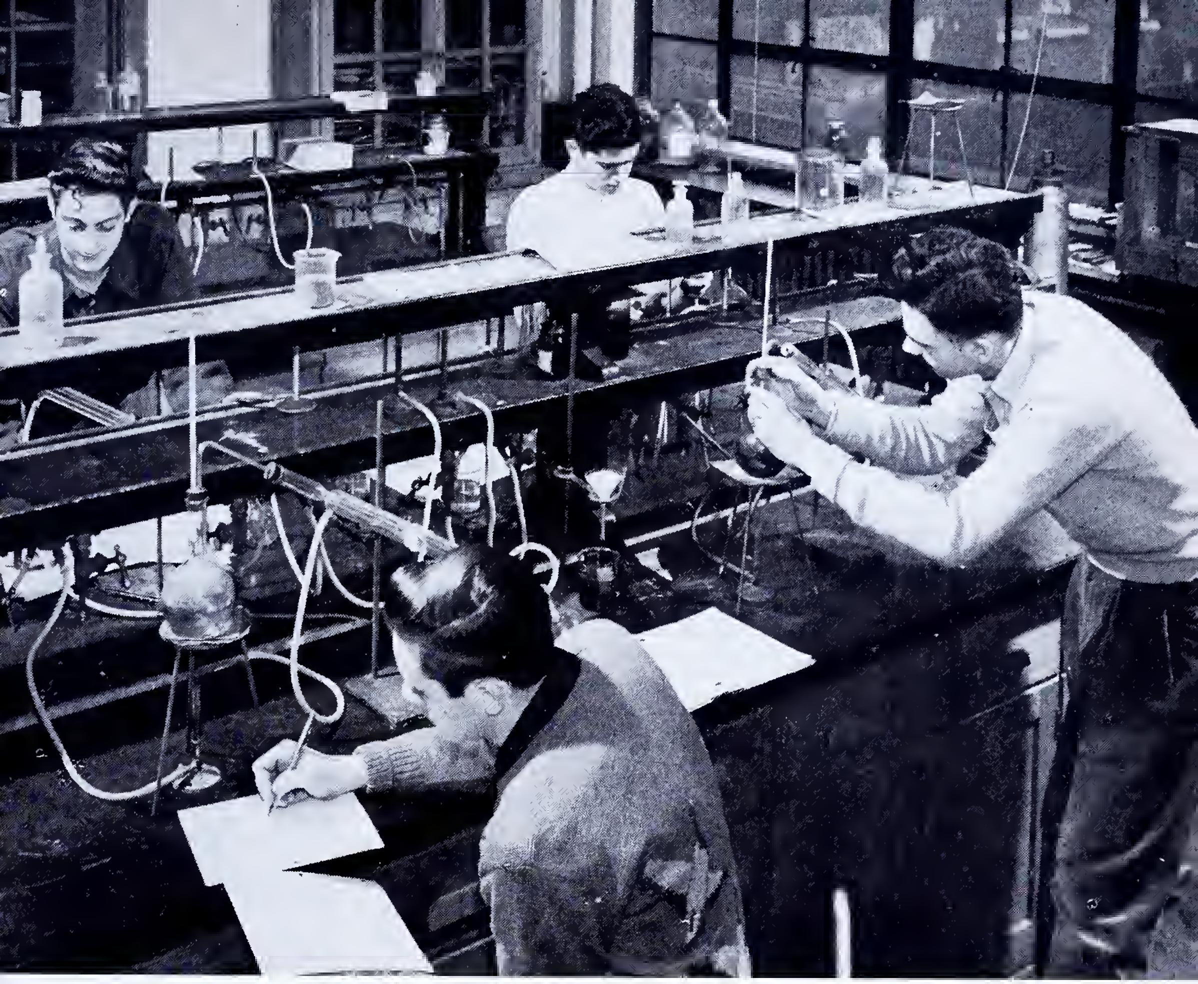
There are two objectives in these units: first, to understand the theory behind the subject; second, to learn something of the manufacture and industrial applications of the substances and materials listed.

The learning experiences will consist mainly of textbook study, together with the preparation of exhibits of the materials when available. Appropriate films are available and should be shown to the class.

Unit XVIII: Nucleonics: Radioactivity, isotopes, agents of transmutation (alpha particles and neutrons), fission

Unit XIX: Organic chemistry: Simple hydrocarbons, alcohols, acids, esters, aldehydes, ketones, isomerism

Unit XX: Equilibria: Le Châtelier's principle, Law of Mass Action



INDIVIDUAL WORK IN CHEMISTRY

UNIT XXI: Molecular weights: Determination by depression of freezing point and elevation of boiling point

UNIT XXII: Equivalent weights and normal solutions

UNIT XXIII: Balancing equations by electron transfer, oxidation-reduction

UNIT XXIV: Metals: copper, zinc, lead, and titanium

UNIT XXV: Nonmetals: phosphorus and silicon

UNIT XXVI: Plastics, rubber, glass, cement, textiles, and foods

Unit XXVII

PENNSYLVANIA'S MINERAL RESOURCES

Content	*Objectives*	*Learning Experiences*
1. Mineral Fuels Anthracite, bituminous coal, coke and its by-products, manufactured gas, petroleum, natural gas, and natural gas gasoline	1. To become conscious of the tremendous mineral heritage of Pennsylvania	1. *Overview by teacher* *Group planning*
2. Nonmetallic minerals Portland cement, lime, clay, glass sand, other sand, gravel, slate, stone, bromine, feldspar, graphite, ocher, rottenstone, salt, water, mineral water	2. To learn where in Pennsylvania the minerals occur	2. *References* a. Chemistry textbooks b. *World Almanac* c. *Pennsylvania's Mineral Heritage,* published by Department of Internal Affairs, Harrisburg d. *Proceedings of the Pennsylvania Academy of Science*
3. Metallic ores and products of primary processing Iron ores, pig iron, Bessemer steel, open-hearth steel, ferro-alloys, chromite, copper, lead, zinc, gold, silver, nickel	3. To learn the chief uses of the minerals of Pennsylvania	3. *Student Projects* a. Prepare a map of Pennsylvania locating the chief sources of the main minerals b. Make a collection of the minerals of Pennsylvania c. Test some of these minerals for their chemical composition d. Learn how to identify the minerals of Pennsylvania by their physical properties e. Show films featuring Pennsylvania resources, such as "Pennsylvania" produced in technicolor by the Standard Oil Company f. Talk by a mine operator
4. Ores of iron and ferro-alloy metals Hematite, bog ore, limonite, magnetite, carbonate ores	4. To learn how coal was formed	4. *Other activities suggested by pupils*
5. Nonferrous metals Copper, magnesium, aluminum, lead, and zinc	5. To learn the waste of topsoil associated with strip mining	5. *Evaluation:* (See p. 190)
6. Nonmetallic minerals and rocks Barite, clay, dolomite, feldspar, granite, graphite, limestone, marble, mica, mica schist, phosphate minerals, salt, sand and gravel, sandstone, serpentine, talc, trap rock	6. To learn why some mine waters in Pennsylvania are very acid	6. *Direct teaching and drill* where need is shown by unit tests
7. Other content suggested by pupils	7. To learn why some minerals of Pennsylvania are extracted and how	
	8. To learn how Pennsylvania waters are being protected	
	9. To realize our duty in conserving our mineral resources for the benefit of those who will follow us	
	10. To learn about jobs in the mineral industries	
	11. Other objectives suggested by pupils	

Unit XXVIII—A Subject Matter Unit

CHEMICAL EQUATIONS AND COMPUTATIONS

INTRODUCTION

Equations to a chemist are somewhat similar to blueprints in industrial arts, in that they depict the ultimate patterns of activity, thereby eliminating much time and cost through trial and error. Equations, therefore, have a definite place in the high school chemistry course.

Practically all high school chemistry texts present four types of reactions with directions for writing and balancing equations. There are several simple rules which may be followed that illustrate the principles involved in certain reactions. At times an introduction to such principles, which are ultimately rules for writing equations, helps the pupil to retain the information because of frequency of presentation.

For those pupils who intend to go on with the study of chemistry much emphasis should be placed on problem-solving, and they should thoroughly master the mathematics of chemistry. Other pupils need not spend much time with this type of work.

In general, the adopted text serves as a good guide as to which problems should be studied, but here again each teacher must determine which material best fits the needs of his particular pupils.

There are many types of problems, ranging from those pertaining to the metric system to those involving calories in foods. This unit deals primarily with those involving atomic and molecular weights.

Some of the most significant problems should be presented to the class in the form of laboratory work with explanations given in the classroom. These are usually quantitative in nature and often include a combination of several principles.

Note: This unit may be reproduced and given to college-preparatory students as a work project.

OUTLINE OF THE UNIT

1. Purpose of Chemical Equations

2. How to Write Equations

a. Function of valence

b. Interpretation of this chemical language

c. Balancing equations
   (1) The least common multiple
   (2) Indicating the valence

d. Practice and drill

3. What an Equation Does Not Show

a. Physical condition of the substance

b. Whether exothermic or endothermic

c. If solvents are used

d. The catalysts necessary

4. Four Types of Reactions

a. Direct combination or synthesis

b. Simple replacement or substitution

c. Simple decomposition

d. Double replacement or double decomposition

5. Summary of the Principles or Rules for the Reaction of Chemicals

6. Some Familiar Reactions in Equation Form

7. Types of Problems

a. Molecular weights

b. Percentage composition of a compound

c. Problems based on chemical equations

d. Review of former problems
   (1) Conversion of metric and English systems
   (2) Gas laws
   (3) Atmospheric pressure
   (4) Density and specific gravity of gases
   (5) Pressure in liquids
   (6) Conversion of temperature for the three thermometric scales

e. The equivalent of magnesium

f. Significant figures

g. Five steps in solving weight problems

PRESENTING THE TOPIC

Most pupils like to write equations for at least one home preparation. This gives them time to comprehend what happens. University students usually are required to complete equations which are hard to balance. College preparatory pupils should have problems sufficiently hard to challenge their abilities. Pupils like equations so well that they are willing to drill eagerly at the blackboard. If the board space is not enough for the entire class, the pupils at their seats should be encouraged to drill at their desks upon scratch paper. If definite patterns of equations are grouped, the pupils usually understand them more quickly. Some rules for writing equations may be given to pupils with samples to be kept in their notebooks. A mimeographed sheet of groups of equations reduces the monotony of this type of work. Knowing how to write equations is perhaps more important than the writing of any particular one; therefore, the principles should be thoroughly mastered.

The combining of the atomic weights to make molecular weights and the changes involved in reactions are usually illustrated on the blackboard with explanations. There is a tendency for the brighter pupils to like this work especially well, but slower members of the class are confused by it. Some of the difficulty in solving the problems may be eliminated by reviewing the fundamentals of arithmetic in the process. It is a good policy for the teacher to establish a pattern or form for the method to be used.

Blackboard drill gives the teacher a good opportunity to see what the individual pupil is doing.

TEACHING AIDS AND SUGGESTIONS

The alert teacher will not only determine the pupils who have not mastered equation writing, but will try to motivate more activity in this field. He should observe his class critically to determine the amount and kind of material to be studied, and should insist upon mastery of sufficient materials to keep the pupils working well, and to give them confidence.

EQUATIONS AND COMPUTATIONS

$E = mc^2$

EXERCISES FOR EQUATION WRITING (Demonstration and Review)

Direct Combination

1. Burning forms oxides:

$2H_2 + O_2 \longrightarrow 2H_2O$

$C + O_2 \longrightarrow CO_2$

2. Some metals and nonmetals combine directly to form compounds:

$2Sb + 3\ Cl_2 \longrightarrow 2SbCl_3$

$Fe + S \longrightarrow FeS$

3. Acid anhydrides plus water form acids:

$SO_2 + H_2O \longrightarrow H_2SO_3$

$CO_2 + H_2O \longrightarrow H_2CO_3$

4. Basic anhydrides plus water form bases:

$CaO + H_2O \longrightarrow Ca(OH)_2$

$MgO + H_2O \longrightarrow Mg(OH)_2$

5. Acid anhydrides plus basic anhydrides form salts:

$CaO + CO_2 \longrightarrow CaCO_3$

$MgO + SO_2 \longrightarrow MgSO_3$

Simple Decomposition

1. Some substances decompose upon heating:

$CaCO_3 + \text{(Heat)} \longrightarrow CaO + CO_2$

$NH_4OH + \text{(Heat)} \longrightarrow NH_3 + H_2O$

2. Some substances decompose by electrolysis:

$2H_2O \longrightarrow 2H_2 + O_2$

$2NaCl + 2H_2O \longrightarrow 2NaOH + Cl_2 + H_2$

Simple Replacement

1. Any element in the electrochemical series will usually displace another element below it from its compound:

$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

2. In the halogen series (F, Cl, Br, I) one will displace another below it from its compounds:

$$Cl_2 + 2NaI \longrightarrow 2NaCl + I_2$$
$$Br_2 + 2AgI \longrightarrow 2AgBr + I_2$$

3. Active metals in water form bases and displace hydrogen:

$$2Na + 2H_2O \longrightarrow 2NaOH + H_2$$
$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$$

4. Metals with strong alkalies liberate hydrogen:

$$2Al + 6NaOH \longrightarrow 3H_2 + 2Na_3AlO_3$$

Double Replacement

1. Some ammonium compounds plus an alkali (soluble hydroxide) form a salt and water and ammonia gas:

$$NH_4Cl + NaOH \longrightarrow NaCl + NH_3 + H_2O$$
$$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$$

2. An acid plus a base forms salt and water (neutralization):

$$NaOH + HCl \longrightarrow NaCl + H_2O$$
$$Ca(OH)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2H_2O$$

3. An acid plus a basic anhydride yields a salt and water:

$$H_2SO_4 + CuO \longrightarrow CuSO_4 + H_2O$$
$$2HCl + CuO \longrightarrow CuCl_2 + H_2O$$

4. A base plus an acid anhydride yields a salt and water:

$$Ca(OH)_2 + SO_3 \longrightarrow CaSO_4 + H_2O$$
$$2NH_4OH + CO_2 \longrightarrow (NH_4)_2CO_3 + H_2O$$

5. A salt plus water forms an acid and a base (hydrolysis):

$$Na_2CO_3 + 2H_2O \longrightarrow H_2CO_3 + 2NaOH$$
$$CuSO_4 + 2H_2O \longrightarrow H_2SO_4 + Cu(OH)_2$$

6. Treat a salt of an acid with an acid having a higher boiling point (usually sulfuric) to prepare the acid of the salt:

$$2NaCl + H_2SO_4 \longrightarrow 2HCl + Na_2SO_4$$
$$2NaF + H_2SO_4 \longrightarrow 2HF + Na_2SO_4$$

7. When salts are treated with an acid having a higher boiling point an acid salt is formed when the solution is heated gently or not at all:

$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$

$NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$

8. A carbonate plus an acid forms a salt, carbon dioxide, and water:

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2CO_2 + 2H_2O$

9. Test for compounds: (A reaction occurs if a precipitate forms)

$AgNO_3 + NaCl \longrightarrow NaNO_3 + AgCl$

$Na_2SO_4 + BaCl_2 \longrightarrow 2NaCl + BaSO_4$

$Ca(OH)_2 + H_2CO_3 \longrightarrow 2H_2O + CaCO_3$

$Pb(C_2H_3O_2)_2 + H_2S \longrightarrow 2HC_2H_3O_2 + PbS$

Some Other Reactions

1. Some metals oxidize in the presence of oxygen to a higher valence:

$4Fe(OH)_2 + 2H_2O + O_2 \longrightarrow 4Fe(OH)_3$

$4CuOH + 2H_2O + O_2 \longrightarrow 4Cu(OH)_2$

2. Metals may be extracted from oxide ores by heating:

$Fe_2O_3 + 3H_2 \longrightarrow 2Fe + 3H_2O$

$PbO + H_2 \longrightarrow Pb + H_2O$

UNIT XXIX—A LIFE PROBLEM UNIT

WHAT SHALL WE EAT?

1. OVERVIEW BY TEACHER AND PLANNING WITH PUPILS
2. CENTRAL OBJECTIVE

To develop, by active participation, a sense of food values which will contribute to effective behaviors in eating

3. CONTRIBUTORY OBJECTIVES—(cooperatively planned)
   a. The realization of the existence of a scientific problem in everyday pupil experience
   b. The behavior of planning laboratory procedures for the best solution of the unit problem
   c. The behavior of passing on to others information learned from experimentation, and to benefit from the learning experiences of others
   d. The behavior of gathering and recording facts from experimentation, and formulating logical conclusions from such facts
   e. Development of the behavior of selecting a well-balanced diet

4. RELATED LEARNINGS—(Cooperatively planned

a. Understanding of the organization and workings of a modern industrial chemical laboratory

b. Further development of laboratory techniques and skills

c. Further appreciation of the importance of the factor of safety in the laboratory

d. Appreciation of the value of working cooperatively with others

e. Development of the behavior of being a wise buyer of foods

5. OVERVIEW

For almost a whole year, you have been studying chemistry. There's one more unit, though, that must be completed before your knowledge of elementary chemistry is complete. That is the topic of foods and food chemistry.

Let us vary our usual procedure this week in order to make an interesting project even more interesting. It has been suggested by members of the class that we organize and operate as if we were employes of an industrial chemistry laboratory, doing work for outside clients. If we do this, you will have an opportunity to utilize the chemistry you've learned thus far in as nearly a practical situation as possible. Instead of performing laboratory experiments from instructions prepared by your instructor, you will make up your own procedures, plan your own laboratory tests, and formulate your own conclusions.

The class periods in this room will be given over to you to organize, to plan, to discuss, and to elaborate on the week's work. In the laboratory, you will be pretty much on your own. I'll be around to help you. We should find out many interesting things about foods.

I would suggest that you elect a director to coordinate the whole program and then select department heads for such departments as carbohydrates, proteins, fats and minerals, and vitamins. This division of responsibility will make possible the completion of the whole project within our limited time. I am expecting you to take this opportunity to show what you can do in chemistry.

6. PRETEST

The purpose of this pretest is to determine problems which may be solved by participation in this unit, and to introduce the project. It will be given during the class period immediately preceding the actual start of the unit activities.

I. Fill in the blanks with words that will correctly complete the following statements:

1. The amount of heat energy obtained from foods is measured in units called ____________________.

2. The chemical reaction between foods and oxygen in living organisms is ____________________ in nature.

3. ____________________ is a good source of protein.

4. Proteins become ____________________ in color when treated with concentrated nitric acid.

5. The ratio of hydrogen to oxygen in carbohydrates is __________ __________ to ____________________.

II. Write the numbers of the items in Column II before the items in Column I which they match.

Column I	*Column II*
______1. Vitamin D	1. Sea foods
______2. Fats	2. Amino acids
______3. Iodine	3. Starch
______4. Glucose	4. Bones and teeth
______5. Proteins	5. Hemoglobin
______6. Calcium	6. Bacteria
______7. Vitamin A	7. Cod liver oil
______8. Iron	8. Carrots
______9. Water	9. Energy storage
_____10. Enzyme	10. Solvent
	11. Sugar
	12. Catalyst

7. ACTIVITIES

First Contributory Objective—The realization of the existence of a chemical problem in everyday experience

The class will organize themselves into departments, each one of which will assume the responsibility for one of the major branches of food chemistry. Departments of (1) carbohydrates, (2) proteins, (3) fats and minerals, and (4) vitamins will suffice. In this class of twenty-nine, seven members will ideally constitute each department. One member of the class will act as *laboratory director* and will act as coordinator of the whole program.

Each department will furnish its own foodstuffs with which to perform the laboratory experiments and tests, and will have the responsibility to determine the types of foods that will best serve for the solution of the unit problem. A minimum of five different foods is suggested for each group.

Teacher Activities

1. Present the overview.
2. Invite student planning.

3. Supervise the election of the laboratory director.
4. Turn the class over to the elected student.
5. Assist in guiding this first class period of the unit.

Secondary Contributory Objective—The behavior needed to gather and organize data concerning foods

During the first meeting of the class concerned with this unit, after the students have organized into departments, each group will confer and discuss the particular problem for which it is responsible. The members will have free access to the books and periodicals pertaining to chemistry that are kept in the room. Those who wish to go to the library may do so. It will be suggested, preferably by the student laboratory director, that each group determine laboratory procedure that will (1) show the presence of the food components studied, and (2) show the properties of these food components.

Teacher Activities

1. Move from group to group to advise pupils at his own discretion, making sure, however, that they do not put too much dependence upon the instructor.
2. Eliminate "blind alleys."
3. Suggest reference sources.
4. Offer encouragement where needed.

Third Contributory Objective—The behaviors of planning laboratory procedures for the best solution of the unit problem

The first laboratory period (90 minutes) will be devoted to the planning of the laboratory procedures for solving the unit problem of food chemistry. Each group will work on its own departmental responsibility in this problem. The student will be reassigned laboratory tables so that members of each group will be together.

Within each departmental group, students will experiment with as many different procedures as possible to determine the presence and the properties of their own particular responsibility. The last half hour of the laboratory period will be devoted to organizing and writing up the procedures determined as best.

The student director will work with each group in turn, so that he or she may obtain a composite understanding of the entire problem, and be able to direct the next day's program.

Teacher Activities

1. Assist in assigning students to group locations in order to get the experimental work started as soon as possible.

2. Move from group to group to answer questions and give advice.

3. Keep an eye on laboratory safety.

4. Encourage the development of the following procedures and give the students the opportunity to suggest other methods.

Fourth Contributory Objective—The behavior of passing on to others information learned from experimentation, and of benefiting from the learning experiences of others

The activities under this objective will take place during two 45-minute class periods. In preparation, the demonstration table will be cleared, and adequate equipment, including all necessary chemicals, will be on hand. The student director will apportion half of each class period to one of the departmental groups, with no particular order of succession.

Each group will then use its allotted time to demonstrate the laboratory procedures that it previously formulated in the laboratory. Different parts of the demonstrations will be executed and explained to the class by different students, so that as many as possible may participate.

During the demonstrations, the students of other departments will take notes and write down the instructions for the procedures being demonstrated. It will be made known to them that the success of the following laboratory period will depend upon their accuracy during these two days.

The periods of demonstration will be free and open to questions and discussion at all times. Caution should be taken, however, that each group keep within its allotted time.

Teacher Activities

1. Prepare equipment and procure necessary chemicals before class for the group demonstrations. This will include the same equipment that is allotted to each student in the laboratory, and such chemicals as will be required, as determined by the activities of the previous day.

2. Turn the class over to the student laboratory director at the beginning of the class.

3. Take a seat at the rear of the room, offering comments and suggestions where necessary.

Fifth Contributory Objective—The behavior of gathering and recording facts from observation and experimentation, and of formulating logical conclusions from such facts

The learning activities under this objective will accomplish two functions. They will develop further learning of the project and will be part of the evaluation procedure of the unit.

The last meeting of the class during the week is a laboratory period of 90 minutes. This meeting will be subdivided into two periods, a 60-minute and a 30-minute period. The first part of the meeting will be devoted to experimental laboratory work. Students will work in their regular departmental groups. The student director will work with any one of them.

Each group will be given five samples of dehydrated food that are unknown to them except by number. Their problem will be to use the laboratory procedures that they and their fellow groups have planned to test the food samples for the presence of carbohydrates, proteins, fats, minerals, and vitamins.

They will work in groups and divide the work so that the complete experiment may be done in this laboratory period. Each student will take notes on his own work in such a manner that others may benefit from the data he collects.

At the end of the first hour, the laboratory work should be finished. During the remainder of the period, after the equipment has been cleaned and put away, the students will begin writing up the experiment. Each student will share his own experimental data with the other students in his group. Free discussion during this time will insure complete understanding of the entire laboratory problem.

The students will be supplied regular write-up sheets so that they may work over the week end in describing the methods used, assembling the experimental data, and formulating conclusions as to the presence or absence of food components in the unknown samples tested.

Teacher Activities

1. Supply five different dehydrated foods, such as dried eggs, dried milk, breakfast cereal, dehydrated potatoes, bouillon. Place in numbered bottles on the shelf at the side of the laboratory. Have all necessary chemicals ready for the period.

2. Explain the time division of the period to the pupils, and let them get started as soon as possible.

3. Move from group to group to supervise laboratory safety and to encourage better techniques.

4. Pass out write-up sheets to each pupil. They should know how to use them without further instruction.

8. EVALUATION

The evaluation of this unit will consist of four parts:

1. Student evaluation by group discussion on the achievement of objectives
2. Teacher-student consultation on the students' record and conclusions of the work of the last laboratory period
3. Results of the following diagnostic short test, to be given during the first class period following the completion of the unit
4. What needs for drill and formal teaching are revealed?

Diagnostic Test

Underline the phrase which most accurately completes each of the following sentences:

1. A good test for starch is the addition of (1) Fehling's solution, (2) nitric acid, (3) a solution of iodine, (4) silver nitrate.

2. Vitamin A is known chemically as (1) riboflavin, (2) carotene, (3) ascorbic acid, (4) nicotinic acid.

3. Vegetables are the best sources of (1) carbohydrates, (2) proteins, (3) fats, (4) minerals.

4. Plants produce carbohydrates by a process known as (1) transpiration, (2) digestion, (3) photosynthesis, (4) phototropism.

5. When Fehling's solution or Benedict's solution is added to a sugar solution and then boiled, the resultant color will be (1) blue, (2) orange, (3) violet, (4) brick-red.

6. Meat when tested will show the presence of (1) carbohydrates, proteins, fats, and minerals, (2) proteins, fats, and minerals, (3) fats and proteins, (4) proteins only.

7. The importance of fats to health is their ability to (1) store energy for future use, (2) manufacture energy from other foods, (3) act as a "shock absorber" for the body, (4) be converted easily into soap.

8. The presence of calcium and phosphorus in foods is essential for the development of (1) hemoglobin, (2) the nervous system, (3) bones and teeth, (4) muscles.

9. Starches can be converted to sugars by (1) adding an acid, (2) the work of enzymes, (3) the action of hormones, (4) fermentation.

10. In planning procedures for laboratory work, it is first necessary to (1) get out all of the necessary equipment, (2) look up existing procedures in a laboratory manual, (3) organize all known facts about the problem and write them down, (4) determine the purpose of the experiment and find out everything possible about it.

9. MATERIALS

The regular laboratory equipment and glassware assigned to each student in a normal chemistry course will suffice for this unit.

In addition to the regular stock reagents kept at the students' benches, the instructor will provide:

1. Iodine solution
2. Fehling's or Benedict's solution
3. $CuSO_4$ solution (dilute)
4. Ethyl ether
5. Potassium ferricyanide solution
6. Chlorine water
7. Chloroform
8. Antimony trichloride solution
9. Metaphosphoric acid solution, 5%
10. 2.6 dichlorophenol indophenol
11. Five samples of dehydrated foods.

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PHYSICS

Scope

Scientific facts and methods have indispensable values for helping human beings solve problems of personal, social, and vocational life. These values should be dominant factors in the teaching of physics. However, potential values are not enough. Successful teaching will transmit potential values into actual pupil behaviors, acquired by practice, and evaluate results accordingly.

The alert teacher will realize that many functional applications to pupil needs must be made in class if transfer values are actually realized in practice. In *general,* pupil needs are the same regardless of geographical areas and community economics. Specifically, however, needs are based upon future aspirations, vocational choices, and the nature of community and regional industries. Skillful teaching and pupil participation in planning will focus instruction toward these goals. Pupils learn what they need to know. Increasing maturity and learning are revealed in broadened needs and greater goals.

Young people must be brought to a realization of the physical resources—on which their community, the nation, and the world depend—and the flow of materials and energy through these areas. Materials and energy should not be thought of in static and far-off terms but in relation to everyday living and industrial prosperity. Their study should result in a better understanding of the activities and needs of the community and the region.

Young people need knowledge of the applications of the principles and laws of physics as an aid in making wise vocational choices and in opening vistas of fields for which they may decide to prepare themselves in institutions of higher learning. The pupil needs, as an integral part of his general education both for conversation and for reading current articles with understanding and appreciation, a knowledge of scientific terms and symbols used in physics.

Teaching which is continually sensitive to the immediate problems of pupils will be most effective in imparting a knowledge of principles and information. As theory is focused in teaching upon actual practical values, both theoretical and functional outcomes are strengthened.

The course in physics deals with the fundamental principles and laws of physics and their practical aspects as they apply to the present-day life situations of the pupils. It points out those concepts and applications which in the present and future are most important. It will aid the pupil in his problems of personal adjustment and will reveal the professional possibilities of advanced work in this special field. It illustrates principles by experimentation, discussion, and guided experience. The objectives and activities are suggestive only. Many others will develop from pupil-teacher planning and teacher guidance.

Sequence

PREPARATORY UNIT: WHY STUDY PHYSICS?

UNIT I: MEASUREMENT; THE USE OF TOOLS

How has precision in measurement helped to develop modern science?

UNIT II: MECHANICS OF LIQUIDS AND SOLIDS

How are the forces exerted by liquids useful to us?

UNIT III: MECHANICS OF GASES

How can gases be harnessed to serve us?

UNIT IV: MOLECULAR PHYSICS

What are the capabilities of "dancing" molecules?

UNIT V: FORCE AND MOTION

What is the relationship between force and motion?

UNIT VI: WORK, POWER, MACHINES, AND ENERGY

How do machines use energy to do work?

UNIT VII: HEAT

How has heat helped man to become master of his environment?

UNIT VIII: MAGNETISM AND STATIC ELECTRICITY

How has utilization of the basic laws of electricity made possible some of the greatest advances in civilization?

UNIT IX: CURRENT ELECTRICITY; ELECTROMAGNETISM

What miracles have been accomplished by moving electrons?
What lies ahead?

UNIT X: SOUND

How does noise retard digestion and raise blood pressure?
"Music hath charms to soothe the savage breast."—Congreve

UNIT XI: LIGHT

How is light connected with all the activities in which we engage every moment of our waking time?

UNIT XII: ELECTRONICS

Will unlocking nature's secrets be a blessing or a curse?

UNIT XIII—LIFE PROBLEM UNIT: WHY IS PRECISION NECESSARY?

UNIT XIV—LIFE PROBLEM UNIT: PHYSICS AND THE AUTOMOBILE

UNIT XV—LIFE PROBLEM UNIT: HOW DID WE GET OUR LIGHTING?

Introducing Units

Pupil-teacher planning is a necessary phase of effective functional education. (See Chapter IV, Evaluation.) In introducing the physics units, provision should be made for this essential motivation. This is especially true in physics, for pupils already know a great deal about the problems.

Pupil-teacher planning may take the form of

1. Overview by the teacher
   Importance of the unit, etc.
2. Group discussion
   a. What do we know now?
      (list on blackboard)
   b. What do we need to find out?
      (list on blackboard)
   c. What work plan shall we use?
      (list problems and committees on blackboard)

The unit outlines presented here are suggestive and flexible. They should be extended to meet specific problems of pupils and the needs of local communities, rural or urban. Variation in topics, problems, and activities will be desirable as circumstances vary.

Evaluation

Data on the evaluation procedures, which should terminate each unit, are suggested in Section 1, Chapter II, "Teaching Science by Units," and in Chapter IV, "Evaluation." Samples of a type of suggested student self-appraisal check list for several units are included at the end of the units. Similar check lists for other units may be readily constructed.

The ideal way to determine the changes which are effected in the pupil as a result of completing the course in physics or studying an individual unit would be to measure the increment of desirable activities which he can and does perform as a result of this study. However, only a few attempts to devise tests for such a purpose have so far been made. There are four measurable outcomes of science study which can be designated and for which tests are available or can be constructed by the teacher: (a) facts; (b) relationships; (c) problem-solving; and (d) attitudes and interests. As to facts, inasmuch as knowledge is essential to adjustment, its proper worth should not be discounted.

1. *Tests for Subject Matter Mastery*

   A. Standardized[1]

[1] Mathematical skills which are basic to problem-solving in physics can be measured by the *Kilzer-Kirby Inventory Test for the Mathematics Needed in High School Physics.*

The *Glenn-Osbourne Instructional Tests in Physics* are primarily for testing units of work during the course, as are the *Michigan Instructional Tests in Physics,* although the latter also includes an initial and a final test.

The *Kirkpatrick-Greene Handbook of Objective Test Exercises in Physics* is a comprehensive series of test items covering the basic concepts of the subject. Several different forms are used for each of the important concepts, making it possible to vary the testing technique for quiz and examination purposes. The teacher may select from the handbook such items as are pertinent to the unit being studied.

B. Teacher-constructed

Using standardized methods, the teacher may construct informal tests suitable to his use. Such may include simple recall, completion items, multiple-choice items, matching exercises. Improved forms of essay-type tests should certainly be included in a testing program for the practice they afford in composition and accurate expression of ideas in the language of physics.

2. *Measurement of Scientific Attitude; Cause and Effect Relationships*

Six main abilities or habits may be listed as conditions to be met in order to possess the scientific attitude; others might be included. These are (1) accuracy in all operations— calculation, observation, and report, (2) intellectual honesty, (3) open-mindedness, (4) the habit of looking for natural causes—cause and effect relationships, (5) the habit of suspended judgment, and (6) the habit of criticism.[1] The teacher may develop his own techniques for such measurement through observation, questioning, and discussion.

Other Criteria for Evaluation

a. Provision for pupil participation in group evaluation
b. Provision for opportunities for self-testing by the learner
c. Committee or group discussion and reports to judge degree of attainment of central objectives
d. Behavior records and anecdotal accounts to gather evidence, to indicate progress with outcomes not readily measurable with formal tests
e. Some form of progress chart to stimulate the pupil toward self-evaluation

Evaluation should be continuous and exercised at all phases of the course from initial planning to final outcomes. Evaluation should emphasize how well the pupil can use what he has learned in functional situations, rather than only how much he can remember.

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[1] Techniques in measuring each of these essentials are presented by Noll, "Measuring the Scientific Attitude," in the *Journal of Abnormal and Social Psychology*, 30:145-54, July, 1935.

A Preparatory Unit

WHY STUDY PHYSICS?

The problems listed embrace principles and concepts which are deemed fundamental and should therefore be included in any well-planned course in physics.

Content	*Objectives*	*Learning Experiences*
1. Why study physics?	1. To acquaint the pupil with outcomes he may expect from a study of physics a. Cultural and historical values b. Desirable habits of discrimination, reflective thinking, and weighing evidence c. Knowledge of important facts and laws necessary to an intelligent understanding of the present environment and life situations d. Enlarged vocabulary e. An increased ability in reading, speaking, and writing f. Greater skill in the application of fundamental principles of mathematics	Listening Making notes Asking questions Functional applications 1. In industry a. Steam engines b. Levers c. Motors 2. In the home a. Ventilation b. Heating c. Insulation
2. How to study physics?	2. To present a general overview of the course and the method the teacher proposes to use in its pursuit 3. To suggest desirable study habits, reading skills, and methods	3. In man a. Joints (fulcrums) b. Force (muscles) c. Eyes (lenses) (See Chapter II, Section 1)

UNIT I

MEASUREMENT; THE USE OF TOOLS

Content

Problems

1. What systems of measurement are most convenient to use? Why?
2. What tools are used to measure? How can you measure accurately to the nearest tenth, hundredth, thousandth of a centimeter?
3. How can you weigh accurately your finger ring?
4. Does the size of the package tell you how much is in it?
5. Other problems suggested by pupils

Objectives

1. To understand the necessity for an accurate system of weights and measures and how our present systems were developed
2. To compare the English and the metric systems of units and measurements and the relative merits of each
3. To develop a certain degree of skill in the use of the tools of measurement: the metric rule, the vernier and micrometer calipers, the balance, the graduated cylinder
4. To appreciate the need for and the use of precision instruments in the world's work
5. To stress the importance of reading labels on all goods purchased
6. Other objectives suggested by pupils

Learning Experiences

1. *Overview*
   Orientation by teacher
2. *Teacher-pupil planning*
   a. What do we know now?
   b. What do we need to find out?
   c. What work plan shall we use?
3. *Committee reports*
   a. Work of the French commission establishing the metric system
   b. Origin of our English units of measurements
   c. Michelson's work in translating the meter into wave lengths of light
   d. The legal adoption of the metric system by Congress
   e. The Bureau of Standards in Washington, D. C.
4. *Laboratory Experiences*
   a. Getting acquainted with the metric system
   Comparison with English system
   b. How are the vernier and the micrometer calipers used?
   c. Finding volumes and weights
   d. Measuring volume of contents in commercial brands of package goods (optional)
5. *Directed study of text and study guide (See Column 1)*

Learning Experiences, continued

6. *Answering summary or self-testing exercises*
7. *Other activities suggested by pupils*
8. *Unit test and other methods of evaluation*
   See Chapter IV and "Evaluation" on page 232.
9. *Reteaching where needed*

Student Self-Appraisal Check List for Unit I—Measurement

The following example of a student self-appraisal exercise may be mimeographed and given to students. It should motivate self-evaluation and participation and provide an overview. Similar check lists for other units may be prepared. Items should be changed to suit local situations.

To the Physics Student:

The following questions are for you to test yourself on what you are learning. Do not che *Yes* unless you know and know that you know.

1. Do you know how to use?

	Yes	*D.*	*No*
a. metric rule			
b. vernier caliper			
c. micrometer caliper			
d. balance			
e. graduated cylinder			

2. Do you know what kind of instruments and units are used to measure?

	Yes	*D.*	*No*
a. length			
b. area			
c. volume			
d. temperature			
e. pressure			
f. speed			

	Yes	*D.*	*No*
g. electric current			
h. heat			
i. speed of sound			
j. light intensity			
k. work			
l. density			

3. Can you explain the meaning of the following words?

	Yes	*D.*	*No*
a. acceleration			
b. ampere			
c. barometer			
d. B.T.U.			
e. caliper			
f. calorimeter			
g. candle-power			
h. centigrade			
i. foot-pound			
j. galvanometer			

	Yes	*D.*	*N*
k. gram			
l. hydrometer			
m. hygrometer			
n. kilowatt			
o. manometer			
p. pyrometer			
q. thermometer			
r. thermostat			
s. watt			
t. wave length			
u. zero (absolute)			

4. Do you know which is the larger: (1) a gram or an ounce, (2) a liter or a gallon, (3 centimeter or an inch?

5. Do you know how to read the meters in your home?

6. What else did you learn in this unit?

7. What help did you give to the work of your class?

UNIT II

MECHANICS OF LIQUIDS AND SOLIDS

Content	*Objectives*	*Learning Experiences*
Problems		
1. What is meant by the density of matter?	1. To learn how to determine the density of a regular and an irregular solid	1. *Overview* Orientation by teacher
2. How can one identify many substances by determining their densities?	2. To learn how to determine the density of a liquid	2. *Pupil-teacher planning* a. What do we know now? b. What do we need to find out? c. What work plan shall we use?
3. How may one determine without damage to the article whether a piece of cutlery is sterling silver or only plated?	3. To understand the applications of density to identification of substances	3. *Pupil projects in hydraulics* a. Water pressure b. Effect of direction on pressure c. Effect of depth on pressure
4. Why may one dam holding twice as much water as a second need no more concrete than the second?	4. To determine the factors upon which the pressure beneath the surface of a liquid depends	4. *Laboratory Experiences* a. Volume and density of water b. Density of solids and liquids c. Pressure in liquids d. Buoyant force of liquids e. Specific weight of solids and liquids f. Hydrometers g. Reports on the applications of the principles learned, as seen in the community
5. What happens when pressure is applied to an enclosed liquid?	5. To learn the effect of pressure applied to an enclosed liquid and its applications	5. *Directed study of text and study guide*
6. What is the pressure on a diver at different depths? Why?	6. To test Archimedes' Principle	6. *Functional applications*
7. Why do some objects float and others sink in the same liquid? In different liquids?	7. To learn the principle of the hydrometer and its applications	7. *Answering summary questions or self-testing exercises*
8. Can iron be made to float? How?	8. To understand Bernoulli's Principle as applied to water flowing through pipes	8. *Other activities suggested by pupils*
9. Why do objects lose weight when immersed in water?	9. To appreciate the contributions which the applications of these principles have made in our daily living and work	9. *Unit test and other methods of evaluation* (See p. 232.)
10. Other content suggested by pupils	10. Other objectives suggested by pupils	10. *Reteaching where needed*

Student Self-Appraisal Check List for Unit II—Mechanics of Liquids and Solids

1. *Useful Knowledge*

	Yes	D.	No
a. Do you know how to determine the density of an irregular solid?			
b. Do you know how to determine the density of a liquid?			
c. Can you explain and test Archimedes' Principle?			
d. Do you understand Bernoulli's Principle?			
e. Can you test a storage battery?			

2. *Vocabulary*

Can you use and explain the following words?

	Yes	D.	No		Yes	D.	No
a. buoyancy				f. surface tension			
b. calorie				g. specific gravity			
c. condenser				h. vaporization			
d. evaporation				i. viscosity			
e. hydraulic				j. volatility			

3. *Principles and Laws*

Can you name six principles or laws that explain or use the following phenomena o[r] activities?

Boating, swimming, floating, daily testing of eggs, dissolving salt, etc.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

4. *Activities and Phenomena*

Can you list five additional everyday activities or phenomena which illustrate any of t[he] following principles?

Liquid pressure, evaporation, volatility, capillarity, osmosis

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________

5. Can you explain what principle is used in most four-wheel automobile brakes?

6. What else did you learn in this unit?

7. What help did you give to the work of your class in this unit?

UNIT III

MECHANICS OF GASES

Content	Objectives	Learning Experiences
Problems		
1. Why do one's ears sometimes ache when going up in an airplane?	1. To learn the similarity in physical behavior of liquids and gases	1. *Overview* Orientation by teacher
2. Why may the carburetor of your car seem to work improperly when climbing a high mountain?	2. To learn the important differences between liquids and gases, i. e., as to expansion and range of compressibility	2. *Pupil-teacher planning* a. What do we know now? b. What do we need to find out? c. What work plan shall we use?
3. How is the force of gravity responsible for air pressure?	3. To study the effect of gravity on gases and the atmosphere	3. *Committee reports or demonstrations on pupil projects* a. Record of daily barometer reading, temperature, and wind direction for one or more weeks; report of the weather bureau for each day; report of the actual weather experienced b. Secure blank weather maps and from daily published reports fill them in and explain their uses c. How official altitude records are established d. The construction, use, and limitations of an altimeter in aviation
4. How can one predict weather by use of a barometer?	4. To learn the construction and use of barometers	
5. How can one measure air pressure?	5. To understand the problems involved and the procedure used in predicting weather	
6. How is a weather map made?	6. To learn how to determine the density of gases	
7. How can one use a barometer to determine altitude?	7. To understand the mechanics of the various types of pumps; their advantages and limitations	
8. How can one force water to the top story of a skyscraper? Why will a common lift pump raise water higher in New York City than in Denver?	8. To understand the applications of Boyle's Law	4. *Laboratory Experiences* a. Weight of air b. Gas and lung pressure e. Boyle's Law d. Field trip to local water pumping station
9. What appliances are operated by air pressure and how do they work?	9. To understand the principles of the air brake and other pneumatic appliances	
10. How can a heavy train be stopped with a few pounds of air?		5. *Functional applications*
11. Other problems suggested by pupils	10. To understand the operation of a siphon	6. *Directed study of text and study guide*
	11. Other objectives suggested by pupils	7. *Answering summary or self-testing exercises*
		8. *Other activities suggested by pupils*
		9. *Unit test; evaluation* (See p. 232.)
		10. *Reteaching where needed*

Student Self-Appraisal Check List for Unit III—Mechanics of Gases

1. *Useful Knowledge*

	Yes	D.	No
a. Can you explain the difference between liquids and gases?			
b. Can you describe the effects of gravity on gases?			
c. Do you know how to construct and use a barometer?			
d. Do you know how to predict weather?			
e. Do you know how to determine the density of gases?			
f. Do you understand how pumps work?			
g. Can you explain how an air brake operates?			
h. Can you explain and apply Boyle's Law?			
i. Do you know how a barometer operates?			
j. Do you understand the kinetic theory?			

2. *Vocabulary*

Can you explain the meaning of the following words?

	Yes	D.	No		Yes	D.	No
a. absorption				f. kinetic			
b. adhesion				g. neon			
c. condenser				h. pneumatic			
d. diffusion				i. refrigeration			
e. dispersion				j. vacuum			

3. *Principles and Laws*

Can you name six principles or laws which explain any of the following phenomena activities?

Shooting a gun, an airplane flying, flying a kite, steam engine, carburetor, drying clothes

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

4. *Daily Activities and Phenomena*

Can you list six other everyday activities which illustrate the following:

Boyle's Law, air pressure, absorption, diffusion, condensation

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

	Yes	D.	No
5. Can you explain the differences between high- and low-test gasolines?			

6. What else have you learned in this unit?

7. What help did you give to the work of your class?

Unit IV

MOLECULAR PHYSICS

Content	*Objectives*	*Learning Experiences*
Problems		1. *Overview* (by teacher)
1. What is matter? In what states does it exist? What are some of its properties?	1. To understand how certain properties of matter make it suitable for specific purposes	2. *Pupil-teacher planning* a. What do we know now? b. What do we need to find out? c. What work plan shall we use?
2. What molecular forces hold a brick building together?	2. To study the forces of adhesion and cohesion and their applications	3. *Committee reports of pupil projects showing* a. Surface tension b. Capillarity c. Water jets d. Camphor boats
3. Is there any difference between steam and water?	3. To understand that certain forces control the state in which a body of matter exists	4. *Other activities suggested by pupils*
4. Why does alcohol rise in the wick of an alcohol lamp?	4. To study capillarity and its applications	5. *Laboratory Experiences* a. Hooke's Law b. Tensile strength
5. Why does compact soil dry out more quickly than soil with a top layer of loose soil?	5. To show that the distortion produced in an elastic substance is proportional to the force producing the distortion	6. *Directed study with text and study guide*
6. Why are soap bubbles spherical?	6. To understand that surface tension is a factor in determining the shape of liquid surfaces	7. *Answering summary or self-testing exercises*
7. Can you make a razor blade float on water?	7. Other objectives suggested by pupils	8. *Functional applications*
8. Why are some insects able to walk on the surface of water?		9. *Unit test; evaluation* (See p. 232.)
9. Other problems suggested by pupils		10. *Reteaching where needed*

Unit V

FORCE AND MOTION

Content	*Objectives*	*Learning Experiences*
Problems		1. *Overview* (by teacher)
1. How is motion measured?	1. To become familiar with the meanings of gravitational units	2. *Pupil-teacher planning* a. What do we know now? b. What do we need to find out? c. What work plan shall we use?
2. What happens when two or more forces act on the same body at the same time?	2. To find the resultant of two forces acting at an angle	3. *Committee reports of pupil projects,* such as a. Hydraulic ram b. Babcock milk tester c. Compensating pendulum d. Inertia
3. How can you apply force in one direction and produce motion in a different direction?	3. To show graphically the composition and resolution of forces	4. *Laboratory Experiences* a. Parallel and nonparallel forces b. Composition and resolution of forces c. The simple crane d. Concurrent forces e. The pendulum
4. Why do so many auto wrecks occur on curves in the road?	4. To study Newton's Laws of Motion and their application	5. *Directed study with text and study guide*
5. How is it possible to work a large horse and a pony side by side?	5. To find the resultant of two forces acting parallel to each other	6. *Viewing films* appropriate to the topic, especially safe driving, stopping distances, etc.
6. How can you use a swinging stick to keep time?	6. To determine the factors upon which the period of the pendulum depends	7. *Functional applications*
7. Why should a baseball not be hit near the end of the bat?	7. To produce a consciousness of the relation of the laws of force and motion to safe driving	8. *Answering summary or self-testing exercises*
8. Other content suggested by pupils	8. Other objectives suggested by pupils	9. *Other activities suggested by pupils*
		10. *Unit test; evaluation* (See p. 232.)
		11. *Reteaching where needed*

Student Self-Appraisal Check List for Unit V—Force and Motion

Useful Knowledge

	Yes	*D.*	*No*
a. Do you know how motion is measured?			
b. Can you explain what happens when two forces act on the same body at one time?			
c. Can you explain the meanings of gravitational units?			
d. Can you explain and apply Newton's Laws of Motion?			
e. Can you determine the factors upon which the period of a pendulum depends?			
f. Can you find the resultant of two forces which act parallel to each other?			
g. Can you find the resultant of two forces acting at an angle?			
h. Can you keep time with a swinging stick?			
i. Can you explain what to do when a car skids sideways?			

Vocabulary

Can you explain and use the following words?

	Yes	*D.*	*No*
a. acceleration			
b. centrifugal			
c. centripetal			
d. component of force			
e. efficiency			

	Yes	*D.*	*No*
f. force			
g. gravity			
h. inertia			
i. mass			
j. motion			

Principles and Laws

Can you name six principles or laws that explain any of the following?

Movement of the earth, flight of a struck ball, work of a steam shovel, a falling apple.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

Daily Activities and Phenomena

Can you list six additional everyday activities or phenomena which illustrate any of the following:

Oscillation, gravity, inertia, momentum, motion, acceleration, component of force

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

	Yes	*D.*	*No*
Can you explain how a Babcock milk tester works?			

What else have you learned in this unit?

What help did you give to the work of your class?

UNIT VI

WORK, POWER, MACHINES, AND ENERGY

Content

Problems

1. How can you measure the rate and amount of work?
2. How much work do you do in going upstairs?
3. What do we mean by power in a machine?
4. Can you get more out of a machine than you put into it?
5. Can a 140-pound boy lift a 5-ton truck?
6. In what ways is friction both a detriment and a benefit to us?
7. How can you lift a grand piano to a second story window?
8. How can a steam shovel lift a two-ton load of ore?
9. How can one man pull a large ship into position at a dock?
10. How can you lift a corner of a house with a screw?
11. Why does an engineer make road grades with as small an incline as possible?
12. Other content suggested by pupils

Objectives

1. To realize that in our physical universe one cannot get something for nothing
2. To realize that work is an accomplishment
3. To understand the kinds of energy; how it is measured; how it is transformed
4. To understand and use intelligently the units of power as applied to machines
5. To attain a certain degree of skill in the use of formulas for motion, force, momentum, work, and energy
6. To determine some of the factors which affect the amount of friction
7. To gain an understanding of how man can multiply his small force
8. To gain an understanding of the principles and uses of the six simple machines
9. To realize that there are ways of saving energy expended by the muscles of one's back and arms in doing daily tasks, and to gain some knowledge of the application of the laws involved
10. Other objectives suggested by pupils

Learning Experiences

1. *Overview* (by teacher)
2. *Pupil-teacher planning*
3. *Committee reports*
   Field trips to watch various types of machines in action
4. *Pupil Projects*
   a. Posters showing the simple machines and their application
   b. Poster tracing energy to the sun
   c. Reports on
      Solar engines
      Diesel and gasoline engines
      Mercury vapor engines
   d. Measuring your horsepower (in climbing stairs)
   e. Relation of area to friction
   f. Starting and sliding friction
   g. Demonstration of distance needed to stop an automobile
5. *Laboratory Experiences*
   a. Levers
   b. Pulleys
   e. Inclined plane
   d. Wheel and axle
   e. Coefficient of friction
   f. Efficiency of machines
6. *Directed study with text and study guides*
7. *Answering summary or self-testing exercises*
8. *Other activities suggested by pupils*
9. *Functional applications*
10. *Unit test; evaluation* (See p. 232.)
11. *Reteaching where needed*

Student Self-Appraisal Check List for Unit VI—Work, Power, Machines, and Energy

Useful Knowledge

	Yes	D.	No
a. Can you measure the rate and amount of work?			
b. Can you explain what is meant by power in a machine?			
c. Can you explain how friction is of benefit to you?			
d. Do you know how the slope of a road grade is measured?			
e. Can you use the formulas for motion, force, momentum, work, and energy?			
f. Can you explain what factors affect friction?			
g. Can you name and explain the principles of six simple machines?			
h. Do you know how to test the efficiency of a pulley system?			
i. Can you explain the operation of a four-cycle engine?			
j. Do you know what is the numerical relationship between the speed of an automobile and the distance needed to stop it?			

Vocabulary

Can you explain and use the following terms?

	Yes	D.	No
a. erg			
b. foot-pound			
c. force			
d. friction			
e. fulcrum			

	Yes	D.	No
f. horsepower			
g. kinetic			
h. torque			
i. turbine			
j. work			

Principles and Laws

Can you name six principles or machines which are involved in any of the following?

Oil rig, steam shovel, windlass, weighing coal, lubrication, automobile clutch, cam

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

Daily Activities and Phenomena

Can you name six additional everyday activities which illustrate any of the following principles or machines?

lever, inclined plane, pulley, work gear ratio, friction

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

Can you describe the meaning and use of the following formulas?

	Yes	D.	No
a. $\frac{F \times D}{t} =$			
b. $\frac{F \times D}{t \text{ min} \times 33{,}000} =$			
c. $\frac{\text{HP output}}{\text{HP input}} =$			
d. B H P			
e. $\frac{\text{B H P} \times 33{,}000}{(\text{lb. of fuel per min.} \times \text{heat value of fuel}) \times J} =$			

UNIT VII
HEAT

Content

Problems

1. How could you measure temperature without a thermometer?
2. How can you make a thermometer?
3. Why does one piece of metal heat up more quickly than another of the same weight?
4. How can you measure heat?
5. What is "specific heat"?
6. How can you determine the proper space to allow between blocks of concrete in a highway or between railroad rails?
7. How does heat change the dimensions of solids, liquids, and gases?
8. How does heat change the state of matter?
9. How cold is an object which can never be made any colder?
10. If heat is added to a solid, is its temperature always raised?
11. How much water vapor is in the air today? What determines the amount which is there?

Objectives

1. To gain an understanding of the important part heat plays in making our lives comfortable and worth while
2. To know how thermometers are made; the various types; their limitations; and their proper use
3. To study the methods for measuring heat and acquire the proper vocabulary to express adequately and accurately our ideas of heat transference and measurement
4. To gain a functional knowledge of the cause of expansion of solids and the problems it makes for engineers as well as in our own experience
5. To gain an understanding of the effect of heat on gases and its application
6. To gain some understanding of the meaning of absolute zero and the uniform behavior of gases in response to changes in temperature
7. To learn how heat energy is transferred from one place to another
8. To learn the meaning of humidity and its effect upon ourselves and our work

Learning Experiences

1. *Overview* (by teacher)
2. *Pupil-teacher planning*
3. *Class visits* by committees to dealers in home heating equipment, cook stoves, air conditioning equipment, refrigerating equipment; to the school heating plant, to a cold storage or manufactured ice plant
4. *Conferences or interviews* with the stationary engineer of a large public or office building
5. If available, a visit to a plant or plants which manufacture any of the above equipment
6. *Pupil Projects*
   a. Research and committee reports
      (1) Cooling systems of automobiles
      (2) Cooling systems of airplanes
      (3) What are the facts about air conditioning?
      (4) Insulation in our homes
      (5) Evolution of the steam engine
      (6) Natural fuel resources: supply, types, uses, economic importance
      (7) Liquefaction of gases and use of such liquids
      (8) Heat and weather

Content	*Objectives*	*Learning Experiences*
12. How much heat is given out when enough steam condenses to form 10 kgs of water?	9. To gain useful knowledge of the principles involved in various types of home heating systems; their advantages and disadvantages, economical operation, and cost	b. Heat conductivity of the common metals (laboratory project) c. Dry ice demonstration d. Low temperatures by evaporation
13. Why will a tub of water placed in a basement or cellar often prevent freezing of vegetables stored there?	10. To gain an intelligent understanding of the meaning of air conditioning and what it should do	e. Measure the relative humidity of various rooms in the same and in different buildings
14. How does a thermostat operate?		7. *Laboratory Experiences*
15. How can a home be heated in winter and cooled in summer from the same equipment?	11. To become familiar with the principles of insulation and their application, especially to homes, heating equipment, and utensils	a. Fixed points of a thermometer b. Coefficient of expansion c. Expansion of gases; Charles' law
16. How does a steam engine convert heat energy into useful mechanical energy?	12. To gain some understanding of heat loss by radiation and its economic importance	d. Specific heat e. Heat of fusion f. Heat of condensation
17. How does a gas engine work?		
18. Do color and finish of your pots and pans affect their efficiency?	13. To understand the effect of large bodies of water upon the climate of adjacent land regions	g. Cooling by evaporation h. Effect of pressure on boiling point; pressure cooker
19. Do size, shape, and material have any effect on the efficiency of pots and pans?	14. To understand the role of evaporation as a cooling process	i. Dew point and relative humidity j. Heat loss by radiation
20. Which would cool the engine in your car more efficiently, water or alcohol?	15. To learn the basic principles and operation of the two general types of heat engines	8. *Directed study with text and study guide*
21. How does a thermos bottle keep hot things hot and cold things cold?		9. *Answering summary or self-testing exercises*
22. Other problems suggested by pupils	16. To learn the construction and principles involved in the thermos or vacuum bottle	10. *Functional applications* 11. *Unit test; evaluation* (See p. 232.)
	17. Other objectives suggested by pupils	12. *Reteaching where needed*

Student Self-Appraisal Check List for Unit VII—Heat

1. *Useful Knowledge*

	Yes	D.	No
a. Can you make a thermometer?			
b. Do you understand "specific heat"?			
c. Do you know how heat causes expansion?			
d. Can you explain how heat causes a change in the state of matter?			
e. Do you know what determines humidity?			
f. Can you explain how heat energy is transferred from one place to another?			
g. Do you understand why clouds do not fall?			
h. Can you explain how Charles' law operates?			
i. Do you know why evaporation produces cooling?			
j. Can you explain how to insulate a house?			

2. *Vocabulary*

Can you explain the meanings of the following terms?

	Yes	D.	No		Yes	D.	No
a. B.T.U.				f. convection			
b. calorie				g. radiation			
c. centigrade				h. specific heat			
d. coefficient of expansion				i. thermal			
e. conduction				j. thermograph			

3. *Principles and Laws*

Can you name six principles or machines that are involved in any of the following?

Oiling machinery, comparison of heating values of fuels, calorimeter, electric refrigerator, heating pad, insulation, heat lamp, clothing

1. ______________ 4. ______________
2. ______________ 5. ______________
3. ______________ 6. ______________

4. *Daily Activities and Phenomena*

Can you name six additional everyday activities or phenomena which illustrate any of the following laws or principles?

Expansion and contraction, transformation of energy, friction, radiation, insulation

1. ______________ 4. ______________
2. ______________ 5. ______________
3. ______________ 6. ______________

5. Can you understand and use the following formulas?

	Yes	D.	No
a. $(F - 32) \times \frac{5}{9} =$			
b. $\frac{9}{5} C + 32 =$			
c. $\frac{\text{Change in length}}{\text{Original length x temperature}} =$			
d. $\frac{\text{Original volume}}{\text{Original absolute temp.}} = \frac{\text{New volume}}{\text{New absolute temp.}}$			
e. $\frac{\text{Original pressure}}{\text{Original absolute temp.}} = \frac{\text{New pressure}}{\text{New absolute temp.}}$			

MAGNETISM AND STATIC ELECTRICITY

Content

Problems

1. Why is the earth called a huge magnet?
2. How can you make a magnet?
3. What is the nature of magnetism?
4. What is a magnetic field?
5. How does the navigator of an airplane use the earth's magnetism?
6. How can you make a map of a magnetic field?
7. Why is it often difficult to comb your hair on a cold, dry day?
8. How can you tell whether an object charged electrically is positive or negative?
9. Why do sparks sometimes flow from your finger to the metal plate when you touch the switch button in turning on the light?
10. Why do gasoline trucks drag a chain over the road?
11. How do you use a condenser to tune your radio?
12. What causes lightning? How does a condenser store up electrical charges?
13. Other problems suggested by the class

Objectives

1. To realize the impact of the development of the electrical industry on our mode of everyday life
2. To appreciate the importance of this industry in which more than six million Americans earn their livelihood
3. To understand the basic rules and laws of safety in relation to handling electrical instruments and machinery, as well as dangers from lightning
4. To determine the nature and shapes of magnetic fields around conductors and magnets
5. To determine some of the factors upon which the nature of magnetism depends
6. To obtain a knowledge of the applications of magnetism which are useful to our work and living
7. To study the laws of static electricity
8. To learn the nature and structure of atoms; how their charges are produced and transferred
9. To gain a useful knowledge of conductors and nonconductors
10. To gain a general knowledge of the types of condensers and their application
11. To get a knowledge of jobs
12. Other objectives suggested by pupils

Learning Experiences

1. *Overview* (by teacher)
2. *Pupil-teacher planning*
3. *Committee research and reports*
   a. Benjamin Franklin's experiments and experiences with static electricity
   b. Atomic structure
   c. Cyclotron and its use
   d. How property is protected from lightning
   e. The uses of condensers
   f. Atmospheric electricity and aviation
   g. Columbus and compass deviation
   h. The gyrocompass and its use
   i. Life and work of Michael Faraday
4. *Laboratory Experiences*
   a. Lines of force
   b. Nature of magnetism and maps of magnetic fields
   c. Static electricity; measurement and identification of charges
   d. Leyden jar; fixed and variable condensers
5. *Demonstrations* •
   Static machine
   Effect of lightning rods, using static machine
6. *Directed study with text and study guide*
7. *Answering summary or self-testing exercises*
8. *Functional applications*
9. *Unit test; evaluation* (See p. 232.)
10. *Reteaching where needed*

Student Self-Appraisal Check List for Unit VIII—Magnetism and Static Electricity

1. *Useful Knowledge*

	Yes	D.	No
a. Can you make a magnet?			
b. Can you explain magnetism?			
c. Can you explain how a compass operates?			
d. Do you understand how a condenser works in a radio?			
e. Can you explain the cause and nature of lightning?			
f. Do you know how magnetism and electricity are related?			
g. Do you understand the structure of an atom?			
h. Can you explain why some materials are nonconductors?			
i. Can you state some safety rules and first aid concerning electricity?			
j. Can you discuss the discoveries of Franklin and Faraday?			

2. *Vocabulary*

Can you explain and use the following words?

	Yes	D.	No		Yes	D.	No
a. ampere				f. Leyden jar			
b. anode				g. neutron			
c. condenser				h. proton			
d. electron				i. resistance			
e. induction				j. Roentgen ray			

3. *Principles and Laws*

Can you name six principles or laws which explain any of the following?

Sparks from a rubber comb, chain at rear of a gasoline truck, snapping on a radio, lightning, Tesla coil, spark coils.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

4. *Daily Activities and Phenomena*

Can you list six additional daily activities or phenomena which illustrate any of the following?

Positive and negative charge, magnetism, condensers, electromagnet, cutting lines of magnetic force, induction.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

5. Can you demonstrate

	Yes	D.	No
a. That electrical charges can be produced by friction?			
b. That like charges repel; unlike attract?			
c. That there is an electric field around a magnet?			
d. That there are two kinds of electrical charges?			
e. How a condenser operates?			

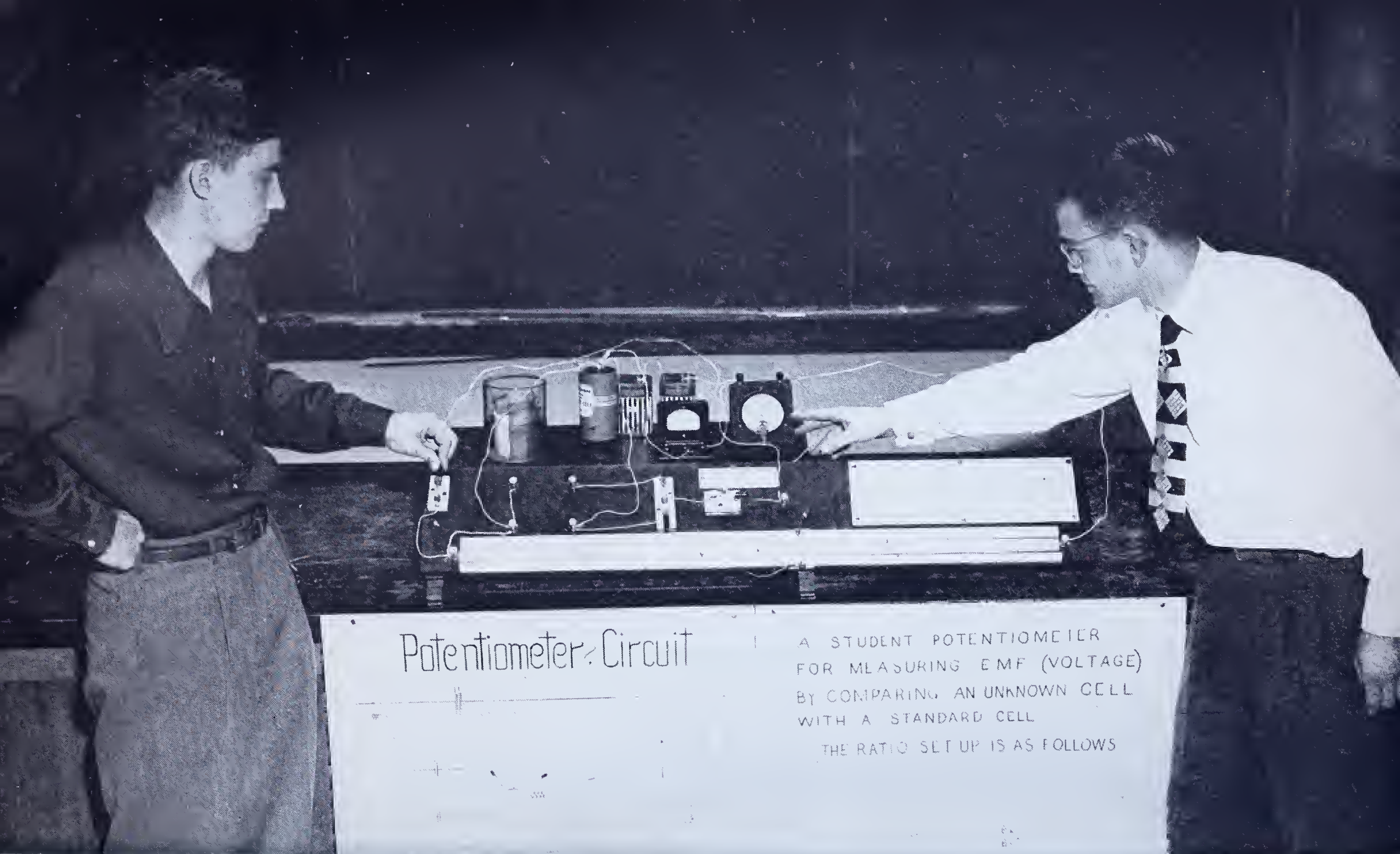
6. What else have you learned in this unit?

7. What help did you give to the work of your class?

UNIT IX

CURRENT ELECTRICITY; ELECTROMAGNETISM

Content	*Objectives*	*Learning Experiences*
Problems		
1. How can you make a voltaic cell?	1. To gain a general understanding of the control and use of moving electrons	1. *Overview* (by teacher)
2. Would a dry cell work if it were dry?		2. *Pupil-teacher planning*
3. How would you connect several cells if you wanted more voltage?	2. To study the factors that determine the voltage and current that a cell or battery can deliver; circuits in series and parallel	3. *Committee research and reports on*
		a. The contributions to society made by Edison, Steinmetz, Faraday, or any other great inventor or scientist in the electrical field
4. How would you connect cells if each appliance in the circuit takes a different amount of current?	3. To study the factors upon which resistance depends and their relationships	b. The operation of a hydroelectric plant
5. What factors determine the voltage and amperage a cell can deliver?	4. To study methods of connecting resistances to obtain best results	c. New inventions that are still needed
		d. How electricity has made the world smaller
6. What is the relationship between volts, amperes, and ohms? How can you determine one if you know the other two?	5. To learn how to control one factor (volts, ohms, amperes) by changing the other two, or just one of them	e. What electricity has done to make the life of young people today different from that of their grandparents' youth
7. What factors influence resistance?	6. To learn methods for measuring resistances	f. Present-day knowledge of the structure of the atom.
8. What methods are used to measure resistance?	7. To gain a general knowledge of how and why to connect resistances in series and parallel	g. How pictures are sent by wire
		h. Commercial electroplating
9. What principles of current electricity does an electrician use in wiring a house for electrical outlets?	8. To become thoroughly familiar with the names and measuring of units of electrical measurement to the end that a label on a home electrical appliance is meaningful	i. The transatlantic telephone
		j. Teletype
		k. Visit the telephone exchange and Western Union office
10. For what are you paying when you pay the electric bill?		l. Visit the local electric power plant
11. How would you connect house lights? bell? telephone? telegraph instruments?	9. To gain sufficient knowledge of electrical circuits to know and practice safety rules in the home, the automobile, and the shop	m. Various types of current rectifiers
		n. Make a chart of important discoveries and inventions in electricity in order of occurrence


Potentiometer Circuit
A STUDENT POTENTIOMETER
FOR MEASURING EMF (VOLTAGE)
BY COMPARING AN UNKNOWN CELL
WITH A STANDARD CELL
THE RATIO SET UP IS AS FOLLOWS

UNIT IX—Continued

CURRENT ELECTRICITY; ELECTROMAGNETISM—Continued

Content	*Objectives*	*Learning Experiences*
Problems 12. How do we use electric current to produce light and heat? 13. Why was the development of the electromagnet of such tremendous importance in our industrial development? 14. How is electricity produced by chemical action? and vice versa? 15. How should one care for a storage battery? 16. How could you put a bright, shiny coating of chromium on your knife blade by using an electric current? 17. How could you make a simple electric motor? 18. How can a motor operate on alternating current? 19. Why can some motors use either A.C. or D.C.? 20. How much does it cost to operate the various home electrical appliances? 21. How can a 6-volt storage battery in your car operate a 12,000-volt spark plug? 22. How does a 2300-volt transmission line deliver only 110 volts to your home? 23. Other problems suggested by class	10. To learn how and why one should care for a storage battery 11. To gain a basic knowledge of electric motors, their types, and their uses 12. To gain an intelligent understanding of electroplating, electrotyping, and their applications 13. To learn about jobs in electrical industries 14. To gain a recognition of the necessity for being careful when near high-voltage transmission lines and transformers 15. To gain an understanding of the construction and use of small transformers in appliances about the home 16. Other objectives suggested by class	4. *Laboratory Experiences* a. The voltaic cell b. Ohm's law c. Factors which vary the resistance of a conductor d. Resistances in series and in parallel e. The Wheatstone bridge f. Heating effect of an electric current g. The electromagnet h. The electric doorbell i. The telegraph j. The storage cell k. Electrolysis and electroplating l. Induced currents m. Study of motors n. Cost of operating electrical appliances o. Transformers 5. *Directed study with text and study guide* 6. *Summary exercises* 7. *Functional applications* 8. *Unit test; evaluation* (See p. 232.) 9. *Reteaching where needed*

Student Self-Appraisal Check List for Unit IX—Current Electricity; Electromagnetism

1. *Useful Knowledge*

	Yes	D.	No
a. Can you make a voltaic cell?			
b. Can you connect cells in series? In parallel?			
c. Do you understand what factors determine voltage and amperage?			
d. Can you explain the relationships between volts, amperes, and ohms?			
e. Do you know what factors influence resistance?			
f. Do you know what Edison, Steinmetz, and Volta have contributed to science?			
g. Can you explain how an electric current can produce light and heat?			
h. Can you explain how electricity can run a motor?			
i. Can you explain how a dynamo can generate electricity?			
j. Do you know the difference between A.C. and D. C. current?			

2. *Vocabulary*

Can you explain and use the following words?

	Yes	D.	No
a. electrolysis			
b. electrolyte			
c. E.M.F.			
d. prefixes: meg, kilo, milli, micro			
e. photo-electric			

	Yes	D.	No
f. polarization			
g. resistance			
h. rheostat			
i. storage cell			
j. Wheatstone bridge			

3. *Principles and Laws*

Can you name six principles or laws which explain any of the following?

Electroplating, fuse blowing out, electric welding, transformers, automobile starter, electric iron

1. ______ 4. ______
2. ______ 5. ______
3. ______ 6. ______

4. *Daily Activities and Phenomena*

Can you list six additional daily activities and phenomena which will illustrate any of the following?

Ohm's Law, polarization, electron flow, current flow, resistance, conductance

1. ______ 4. ______
2. ______ 5. ______
3. ______ 6. ______

5. Can you understand and use the following formula?

	Yes	D.	No
a. $I = \frac{E}{R}$			

6. What else have you learned in this unit?

7. What help did you give to the work of your class?

UNIT X
SOUND

Content	*Objectives*	*Learning Experiences*
Problems 1. How is sound produced and how does it travel? 2. How does one hear a sound? 3. How fast does sound travel? 4. What makes one sound louder than another? What is an echo? 5. How is sound reinforced? 6. How can two sounds produce silence? 7. Can you explain resonance and how it is produced? 8. Why are the acoustics better in some theaters than in others? 9. What is the difference between a musical sound and a noise? 10. How do musical sounds differ from each other? How is a musical sound made? 11. How does a vibrating string or air column produce tones of different pitch and quality? 12. Why does a dog sometimes howl when a violin is being played? 13. How does a designer of a pipe organ determine how long to make each pipe? 14. Other content suggested by class	1. To appreciate the good and bad qualities of sound, and their effect on the listener 2. To appreciate how we employ sound to give us music, entertainment, and means of communication 3. To learn the conditions which produce sound audible to the human ear and how to control them 4. To study the conditions which cause the transmission of sounds and production of echoes 5. To study the conditions for resonance and its applications to musical instruments 6. To measure the velocity of sound 7. To learn why some auditoriums have "dead spots" 8. To learn the difference between a musical note and a noise 9. To learn methods for controlling noise, echoes, and resonance 10. To learn about jobs 11. To determine how the frequency of a vibrating string depends upon its length, tension, diameter, and mass per unit length	1. *Overview* (by teacher) 2. *Teacher-pupil planning* 3. *Committee research and reports* a. History of music b. History of various musical instruments c. The Hammond organ d. The sonic depth finder e. The phonograph f. Electrical transcription for radio g. The tempered scale h. The diatonic scale i. Balance in a symphony concert j. Beats and tempo in orchestration; harmony, themes, syncopation, etc. k. Noise control l. Measuring distance by sound 4. *Laboratory Experiences* a. Transmission of sound b. Frequency of a tuning fork c. Velocity of sound d. Vibrating bodies e. Study of resonance f. Laws of vibrating strings g. Determination of wave length with open tube and with a closed tube 5. *Functional applications* 6. *Answering summary or self-testing exercises*

UNIT X—Continued

SOUND—Continued

Content	*Objectives*	*Learning Experiences*
	12. To determine the wave length of a tone from a tuning fork	7. *Directed study with text and study guide*
	13. To gain a general knowledge of the types of instruments used in a symphony orchestra	8. *Unit test; evaluation* (See p. 232.) 9. *Reteaching where needed*

Student Self-Appraisal Check list for Unit X—Sound

1. *Useful Knowledge*

	Yes	D.	No
a. Do you know how sound is produced and how it travels?			
b. Do you understand how sound affects the ears?			
c. Can you explain how two sounds can produce silence?			
d. Can you explain how an automobile muffler works?			
e. Do you know what creates good acoustics in a theater?			
f. Can you explain the difference between noise and music?			
g. Do you know how many intervals there are on an even-tempered scale?			
h. Do you know what maximum noise level is considered desirable in an office?			
i. Can you draw a diagram of a telephone transmitter and receiver?			
j. Can you describe the difference between pitch and loudness?			

2. *Vocabulary*

Can you explain and use the following words?

	Yes	D.	No
a. beat			
b. chord			
c. chromatic scale			
d. decibel			
e. diatonic scale			
f. discord			
g. echo			
h. frequency			
i. node			
j. octave			

3. *Principles and Laws*

Can you name six principles or laws which explain any of the following?

Singing, listening to music, speaking, bell ringing, whistling, radio, phonograph, telephone, sonar.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

4. *Daily Activities and Phenomena*

Can you list six other daily activities or phenomena which illustrate any of the following?

How sound is transmitted, volume of sound, absorption of sound, pitch, sympathetic vibrations, acoustics.

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

5. *Can you demonstrate*

	Yes	D.	No
a. How to measure the speed of sound?			
b. Methods of noise control?			
c. How to measure distance by sound?			
d. The measurement of wave lengths?			
e. Overtones?			

6. What else did you learn in this unit?

7. What help did you give to the work of your class?

UNIT XI

LIGHT

Content

Problems

1. How can you take a picture with a box which has only a pinhole in one end?
2. How can you select work lights that are easy on your eyes?
3. Where does light come from and how does it travel through space?
4. How does a mirror enable you to see yourself?
5. What effect has the shape of the mirror on what you see in it?
6. How are images formed by refracted light?
7. How does an optician use refraction of light to help you see better?
8. How is refraction of light related to speed of light?
9. How do you use a lens to form an image?
10. How does a compound microscope enable you to see objects too tiny to be seen with the naked eye?
11. How is the eye like a camera?

Objectives

1. To learn how light travels and how an image may be formed through a pinhole
2. To gain a knowledge of intensity of light and how to control illumination properly
3. To determine how light is reflected and the laws of reflection and reflected images
4. To study types of mirrors and images
5. To gain a useful knowledge of refraction of light in various media and its application in daily living
6. To gain a general understanding of the parts and operation of a telescope, a microscope, and binoculars
7. To gain a useful knowledge of the construction and operation of the human eye to the end that sight may be conserved
8. To gain an intelligent understanding of the way pictures appear to move on a motion picture screen

Learning Experiences

1. *Overview* (by teacher)
2. *Teacher-pupil planning*
3. *Committee research and reports*
   a. Make and use a pinhole camera
   b. Visit a local motion picture projection room
   c. Demonstrate optical illusions to the class
   d. Visit a photographer's studio and darkroom
   e. Some great solar eclipses
   f. Color printing
   g. Color photography
   h. The new 200-inch telescope
   i. The uses of mirrors in the home
   j. Applications of physics to astronomy
   k. The use of the spectrograph in science and industry
4. *Laboratory experience*
   a. To find the candle-power of a lamp
   b. Reflection of light from a plain mirror
   c. Images formed by plane and spherical mirrors

Content	*Objectives*	*Learning Experiences*
Problems		
12. Why does an automobile appear to become smaller as it gets farther away from you?	9. To gain useful knowledge of the cause of color formation and its application in daily living	d. To determine the focal length of a spherical mirror
13. What are some common eye defects and how can they be corrected?	10. To learn about jobs	e. To determine the index of refraction of glass
14. Are the pictures on a motion picture screen actually moving?	11. Other objectives suggested by pupils	f. To determine the focal length of a convex lens; to study the images formed by lenses
15. What causes the colors in your clothes?		g. Optical instruments
16. What are spectra and how are they produced?		h. How to find the magnifying power of a small telescope
17. Why are some colors more pleasing than others?		i. How is color produced?
18. What is color blindness?		5. *Directed study with text and study guide*
19. How are different colors produced?		6. *Answering summary or self-testing exercises*
20. How much light is needed by the human eye under different conditions?		7. *Functional applications*
21. Why are different walls of the same schoolroom sometimes painted in different colors?		8. *Unit test; evaluation* (See p. 232.)
22. Does color have any effect on your mood?		9. *Reteaching where needed*
23. Other problems suggested by pupils		

UNIT XII
ELECTRONICS

Content	Objectives	Learning Experiences
1. What are X rays and radium rays?	1. To gain an intelligent understanding of the value of radium and radio-activity to our daily life and health	1. *Overview* (by teacher)
2. What is radioactivity?	2. To appreciate the socio-economic problems raised by the discovery of how to release atomic energy, and the need for its control	2. *Teacher-pupil planning*
3. What are cathode rays? Of what value are they to man?	3. To learn some of the ways we can apply our knowledge of atomic energy to improving man's health and enjoyment of life	3. *Committee research and reports*
4. What is the nuclear structure of uranium?	4. To gain an intelligent understanding of the elementary principles of radio and television	a. Visit the X-ray department of a hospital.
5. How can the nuclear energy of uranium be released?	5. To study some of the ways we employ moving electrons to work for us and safeguard our valuable possessions	b. Set up an X-ray tube and take an X-ray picture
6. Can the binding energy of the nuclei of atoms of other elements be released?	6. To learn about jobs	c. Build a simple radio receiver
7. What were some of the problems which had to be solved before the atomic bomb could be perfected?	7. To gain some knowledge of the invisible spectra and their applications	d. Visit a broadcasting station
8. How can atomic energy be applied to peacetime uses?	8. To study the effects of atomic weapons	e. Visit a telecasting station (video)
9. How long before your car is powered with atomic energy?	9. To learn what to do when an atomic bomb explodes	f. Conduction of electricity
10. How are radio waves produced and received?	10. Other objectives suggested by class	g. The story of radium
11. How do sounds change the shape of radio waves?		h. The present status of television
12. How does a radio work?		i. The uses of radio in aviation
		j. Transatlantic radio communication
		k. The amateur's place in the development of radio
		l. Sending pictures by wire and radio
		m. The photoelectric eye
		n. Possible future improvements through electronics
		o. Atomic energy; its use and abuse
		p. Construct a Geiger-Mueller counter
		q. Report on what to do when an atomic bomb explodes

UNIT XII—Continued

ELECTRONICS—Continued

Content	*Objectives*	*Learning Experiences*
13. How are light waves made to control sound and mechanical devices?		4. *Laboratory Experiences* The vacuum tube
14. How can you take a picture without visible light?		5. *Directed study with text and study guide*
15. What causes your skin to tan in the sunlight?		6. *Functional applications*
16. What are cosmic rays?		7. *Answering summary or self-testing exercises*
		8. *Unit test; evaluation* (See p. 232.)
		9. *Reteaching where needed*

From page 263

5. Can you demonstrate by model or diagram

	Yes	*D.*	*No*
a. How an electronic tube operates?			
b. How a radio operates?			
c. How a television tube operates?			
d. How atomic fission occurs?			
e. A chain reaction?			

6. What else did you learn in this unit?

7. What help did you give to the work of your class?

Student Self-Appraisal Check List for Unit XII—Electronics

1. *Useful Knowledge*

	Yes	D.	No
a. Can you explain how X rays are produced?			
b. Do you understand the nature of radioactivity?			
c. Can you explain the structure of an atom?			
d. Can you indicate by diagram how the nuclear energy in the uranium atom is released? What is the effect?			
e. Can you explain some of the problems that had to be solved before the atomic bomb was perfected?			
f. Do you know how the energy of uranium atomic fission compares with that of an equal amount of coal?			
g. Can you explain the nature of radio waves?			
h. Can you discuss the uses of radium, X rays, and atomic energy by man?			
i. Do you know what contributions to science have been made by: Crookes, Thompson, Roentgen, Edison, Marconi, and DeForest?			
j. Can you explain how to save yourself from an atomic bomb explosion in open country? In a city? In a house?			

2. *Vocabulary*

Can you explain and use the following words or terms?

	Yes	D.	No
a. alpha rays			
b. beta rays			
c. cathode rays			
d. chain reaction			
e. cyclotron			
f. electromagnetic spectrum			
g. filament			
h. fission			
i. fluoroscope			
j. gamma rays			
k. Geiger counter			
l. grid			

	Yes	D.	No
m. iconoscope			
n. kinescope			
o. magnetic pickup			
p. plate			
q. proton			
r. radar			
s. radioactivity			
t. "snooperscope"			
u. thermo couple			
v. triad			
w. ultra-violet			
x. vitamin D			

3. *Principles and Laws*

Can you name ten principles or laws which explain any of the following?
atom bomb, radio waves, video, sun-tanning, photography, electric eye, radar, electron microscope

1. ____________ 6. ____________
2. ____________ 7. ____________
3. ____________ 8. ____________
4. ____________ 9. ____________
5. ____________ 10. ____________

4. *Daily Activities and Phenomena*

Can you list six other activities or phenomena which illustrate the following?
fluoroscope, vitamin D, kilocycles modulation, radio frequency waves, audio frequency

1. ____________ 4. ____________
2. ____________ 5. ____________
3. ____________ 6. ____________

Continued at bottom of opposite page

Unit XIII—A Life Problem Unit

WHY IS PRECISION NECESSARY?

OBJECTIVES

General:

To develop a realization of the economic necessity for an accurate system of weights and measures; and an understanding of the origin and development of our present system

Specific:

To compare the English and the metric systems of units and measurements, and the relative merits of each

To develop a certain degree of skill in the use of tools and measurement: the metric rule, the vernier and micrometer calipers, the balance

To appreciate the need for and the use of precision instruments in the world's work

To stress the importance of reading labels on all goods purchased

OVERVIEW

Man's progress really started when he stopped guessing and began to make measurements. The modern automobile is an intricate product and each part must fit with precision; hence it must be manufactured in accordance with strict standards of measurements. These parts may be manufactured in as many as 60 to 100 different plants and brought together on the assembly line; thus we can see how a common system of measurement must be used and all instruments of measurement calibrated to a standard. Engineers speak of the measurements of parts for large machines in thousandths of an inch and the parts of a watch are measured in ten-thousandths of an inch. The parts of a large suspension bridge are all manufactured previous to assembly and according to specifications of its architect and designing engineer; yet when completed, everything fits to within a small fraction of an inch. Engineers are able to tunnel under the Hudson River, starting from both sides simultaneously and meet exactly in the center. All this and more is made possible because man has invented systems and tools for making such fine measurements.

Did you ever try to build anything which called for measurements? Did your finished product have all parts fitting perfectly and the finished dimensions exactly as planned?

Only in recent years have units for measuring various physical quantities become standardized. Some of the sources of units used in ancient and modern times are quite amusing. What is the *cubit* used in Bible times? How much is a handful? A pinch? A machinist today can measure accurately to two-millionths of an inch. Precision in measuring is all-important today. It would also be a boon to manufacturing firms if there were a universal system of measurements which would eliminate the need to translate specifications from one system to another for foreign trade.

CONTENT OUTLINE AND ACTIVITIES

Problems	*Subject Matter*	*Activities*
What systems of measurements are most convenient to use? Why?	The English System: *Linear:* mile, rod, yard foot, inch *Volume:* cubic yard cubic foot cubic inch gallon quart pint ounce *Weight:* ton (long and short) pound, ounce (avoirdupois— troy)	1. *Preview* 2. *Committee or group assignments of research and reports* a. Work of French commission establishing the metric system b. Origin of our English units of measurements c. Michelson's work in translating the meter into wave lengths of light d. The legal adoption of the metric system by Congress e. The Bureau of Standards and its work in Washington, D. C.
What tools are used to measure? How can you accurately measure to the nearest tenth, hundredth, or thousandth of a centimeter? How could you accurately weigh your finger ring?	The metric rule The vernier caliper The micrometer caliper The platform balance The beam balance The graduated cylinder	3. *Laboratory Experiences* a. Getting acquainted with the metric system; correct measurement, and use of tools b. How are vernier and micrometer calipers used? c. Finding volumes and weights d. Measuring volume of contents in commercial brands of package goods (optional) e. Other activities suggested by pupils
Does the size of the package indicate how much is in it?	City ordinances, state and federal laws regulating weights, scales, and measuring devices used by merchants	4. *Working problems with metric units of measurement* *Continuous use of references* 5. *Answering summary or self-testing exercises* 6. *Unit test and other methods of evaluation* 7. *Reteaching where needed*

SURVEY QUESTIONS

1. Does the size of a package tell you how much is in it?
2. Can you tell how much a container holds by just looking at it?
3. Do you know the basic units of the metric system?
4. Do you know the origin of the metric system? Which unit was developed first?
5. a. Is it safe to assume that a steel tape used to measure distances purchased at one store is as accurate as one purchased at another?
   b. What precautions are taken in manufacturing steel tapes to assure a reasonable degree of accuracy?
   c. What precautions are taken by governmental agencies to insure the public of accurate measure when purchasing materials?
6. Do all the countries of the world use a common system of weights and measures?
7. Can you give any disadvantages in using more than one system in world trade?
8. What is the legal unit of length in the United States?
9. What kind of measurements should be made with the vernier caliper? With the micrometer caliper?
10. Why are precise measurements essential in scientific work? In industry?

MATERIALS

Meter sticks, graduated cylinders (25, 50, and 250 ml.), platform balance (at least three to a class of 12), beam balance, vernier calipers, micrometer calipers, objects of varying sizes and material to be measured, wire of different diameters, small cylinders (solid and hollow), weights, packages of cereal, canned goods, etc.

Textbook and a study guide. This may be mimeographed directions constructed by the teacher or by teacher and pupils or may be a good workbook

QUESTIONS FOR SELF-EVALUATION

These questions are not to be attempted until the learner feels that he has satisfactorily completed his study of the unit. They should be treated as a self-examination and not as a tool for determining school marks.

1. What nation originated the metric system?
2. What was the first unit established? Define it.
3. This compares roughly to what English unit?
4. What units are used in the laboratory to measure small lengths?
5. What is the common unit of volume used in the laboratory?
6. The metric unit of capacity (liquid measure) is the __________.
7. This unit is equal to the volume of a cube __________ cm. on each edge.

8. What is the metric unit of mass (weight)?
9. This is the weight of one ____________ of water.
10. It is equal to ____________ pounds.
11. What unit of weight is most commonly used in the laboratory?
12. This is the weight of one ____________ of water.
13. Approximately how many grams in an ounce?
14. Express 3.54 m. as centimeters.
15. Express the same length as millimeters.
16. What is the volume of a box 6 cm. x 15 cm. x 1.2 m.?
17. What is the weight in grams of the water this box would hold?
18. What is its weight in kilograms?
19. Is a 100-meter dash more or less than a 100-yard dash?
20. How many kilometers between two cities that are 56 miles apart?
21. What measurements should be made with the vernier caliper?
22. What measurements should be made with the micrometer caliper?
23. Name several industries or trades where use of micrometers or verniers is essential for measuring?
24. If you were going to replace a water pipe, would you measure its *inside* or its *outside* diameter? Why?
25. Which has the larger diameter, a wire with a *small size* number, or one with a *large size* number?

Evaluation

1. Try to answer the survey questions on pages 266-267 correctly.
2. Answer the questions for self-evaluation without reference to textbook or notes; then check your answers with a text or a master sheet secured from your teacher.
3. Your teacher may wish to discuss parts of the unit with you to see how well you have mastered the questions; or you may wish to discuss the items with groups of your fellow students.
4. Take the unit test and evaluate your results.

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Unit XIV—A Life Problem Unit

PHYSICS AND THE AUTOMOBILE

OBJECTIVES

General

1. To promote a better understanding of the complexity, the care, and the efficiency of the automobile
2. To make students familiar with the basic operation of the various units of which a car is contructed and to show how the principles of physics are involved in the operation of the automobile

Specific

1. To develop attitudes that will cause students to become better drivers because of an understanding of the safety limitations of the automobile
2. To bring out basic concepts which will make future drivers better qualified with regard to economy in the operation of the automobile
3. To make students aware of the gradual development of the automobile and how man has been affected by this development
4. The realization that men are constantly striving to make life more pleasant and more safe by new developments in the automotive field
5. To develop the realization that science plays an ever increasingly important role in all of the basic industries of the country

BASIC ORIENTATION AND ORGANIZATION

1. A discussion period with the class should be held at the outset to determine method of attack and general plan to be followed in this unit, also types of materials to be used during the research period, where they may be found, length of time to be allowed for research, methods of culminating activity, and tentative dates for reports
2. Divide the unit into six parts
   a. History of the automobile
      Stress pioneers in the field—The evolution of the automobile to the present day. Make use of pictures and films
   b. The power unit, including engine fuel system, lubrication and cooling
      Stress basic operations—principles of physics involved
   c. The power train: clutch, transmission, drive shaft, and differential
      Stress operation—principles of physics involved
   d. The frame, body, steering and suspension systems
      Stress operation—basic principles of physics involved. Make use of pictures, drawings, and films
   e. The braking and electrical systems
      Principles of physics involved. Use diagrams and films
   f. New developments in the automotive field
      Use pictures, diagrams, and charts

3. Class organization
   Allow class to divide itself into six groups and select the topic in which each group is most interested. Each group should select a chairman, so that the work of the group can proceed efficiently

SUPERVISED ACTIVITIES

1. Permit students to organize their work in their groups. Teacher should be prepared to suggest activities, sources, and other information to each group
2. During class periods students should be allowed and encouraged to go to libraries, and to study available films and filmstrips and models in preparation for their reports
3. Students should be allowed and encouraged to visit salesrooms, and garages, to interview expert automobile mechanics, salesmen and garage owners, and to send to automobile companies for free literature on the car at any available time.
4. Several days for this study should be allowed, and two or three field trips to garages should be arranged
5. A field trip to the automotive shop of the school, if the school has such a shop, would be very helpful

CULMINATING ACTIVITIES

Oral reports by the group chairmen or other individuals, depending upon the setup within the group. Films, filmstrips, diagrams, pictures, models, and automobiles, with verbal explanations by students, should make up these reports

EVALUATION

Any tests used should be general in nature and based on reports given and attitudes which have been developed

Unit XV—A Life Problem Unit

HOW DID WE GET OUR LIGHTING?

INTRODUCTION

This report on the history of artificial lighting from the early torch to the modern incandescent lamp, cuts across the so-called subject boundary lines. The area of interest includes not only the subject matter of physics, but also that of chemistry, ancient history, and mythology. Students will develop needed understandings and expanding concepts of their environment.

The student, with proper understanding of the selected project and with proper guidance, naturally follows the pattern as developed herein. Some will make a chart listing the discoveries in chronological order; some, a large drawing of the various types of artificial lighting systems, with suitable inscriptions or labels underneath each type; others will make models or obtain replicas of each type of artificial light. Each person works on such a project in his own way and thereby reveals his interests, attitudes, ideals, habits, and general behavior patterns.

The trend toward a functional curriculum results in the teaching of the whole person. Unitary organization of subject matter and learning exercises are emphasized with decreasing fragmentary assign-study-recite-test-restudy-retest sequence.

The following report may be termed a creative project on artificial lighting.

STUDENT PROJECTS

Student planning and research, individually or by committee, may develop the following types of construction demonstrations and reports:

1. The Torch

Torches and camp fires gave man his first means of light, and are today the only man-made light of some primitive peoples.

The Shetland Islanders used to make a torch by sticking a wick in the throat of a fat stormy petrel, and the Indians of the North Pacific coast made similar use of a little dried fat smelt called the candlefish.

2. Stone Lamp

Many well-wrought terra-cotta lamps have been found in long-buried cities in Mesopotamia, some dating to 7000 or 8000 B.C.

The lamp of the cave dweller, by the light of which he scratched strange drawings on the cave walls, was made of an animal's skull, a sea shell, or a hollowed stone. With a rude wick of moss, vegetable fiber, or rushes, it burned animal fat or fish oil. This type of lamp the Eskimos and some Laplanders use today.

3. Metal Lamps

Metal lamps, made of bronze by prehistoric lake dwellers, have been found in Swiss lakes. The traditional "lamp of learning" of ancient Greece and Rome, was a shallow round or oval dish, of terra cotta or metal, with a handle at one end and a spout for a cloth or tow wick at the other.

The "Betty lamps" were brought to America by the Puritans on the Mayflower. They were of Dutch origin and made first of iron, then of tin or brass. Benjamin Franklin is credited with introducing two wicks close together to give brighter light and less smoke and using flat wicks made of closely braided cotton.

4. Oil Lamps

Aimé Argand, a Swiss chemist, revolutionized lamps (in the 18th century) by placing a flat wick around a hollow tube, allowing air to reach the center of the flame. With more air and a better draft, the flame burned more carbon and gave less smoke. By adding a glass chimney he made the lamp completely smokeless. He was granted a French patent on this improvement in 1784.

Many modifications of this lamp were introduced.

5. Camphene Lamps

About 1850, camphene, made from turpentine, was among the first substitutes for animal oils, but its tendency to explode kept it from coming into general use. Prior to this, lamps burned animal fats, whale, fish, and vegetables oils. Lanterns of lighthouses burned whale oil.

6. Kerosene Lamps

Kerosene, safe and cheap, oftentimes called coal oil, mineral oil, paraffin oil, and petroleum oil, came into general use about 1860.

Lanterns, portable lamps to be carried in the wind, were used in ancient times at the head of marching armies, in religious rites, and by soothsayers in their auguries. Before the introduction of the glass chimney, a lantern was usually a candle shielded by a metal guard with holes cut through to shed light. In the 16th and 17th centuries, horn replaced the metal guard; hence came the term "lanthorn." Later oil-burning lanterns were used with glass chimneys.

Railroad men still signal at night with oil lanterns as well as electric. The dark lantern, or "bull's eye," has a round lens to concentrate the light. A sliding shutter may cover the lens.

7. Candles

The wax candle probably originated in Phoenicia. The Old Testament mentions candles and candlesticks, but not their materials. Candles of animal fat appeared about the 2nd century A.D. and in the 11th century the English made candles by dipping sticks in tallow. Later came candles of spermaceti, a wax from the heads of whales, and "composites," of stearic acid and stearin, popular about 1830.

The wick of the early candles was only partly consumed since it remained in the flame shielded from the oxygen of the air.

In colonial days, candles were made by dipping a wick into hot tallow, allowing it to cool, and redipping many times. These "tallow dips" were then thrust into hot water and shaken, to paint or "feather" them, and so keep them from dripping.

Candles at present are molded. They are usually made from paraffin, a refined wax obtained from crude petroleum, strengthened with a mixture of stearic acid. The pleasant light of candles is chiefly used in religious services and to give charm to homes.

The candlestick has long been a handsome ornament. The Greeks and Romans made beautiful candelabra, and in Europe artists wrought fine designs for candlesticks in iron, bronze, and copper. In the 17th and 18th centuries, candlesticks of silver, silver plate, and Sheffield plate, as well as of china and glass, glittered on elegant tables.

8. Gas Lamps

Brighter light became available with the introduction of gas in the United States about 1806. Its use spread rapidly after the development of the Welsbach mantle, and was only replaced by the incandescent electric lamp.

9. The Electric Lamp

Edison's first successful lamp (1.4 lumens per watt) was invented in 1879. This glaring electric light, hanging from the end of a green cord, was far from beautiful. People have since learned how to make electric lighting beautiful. In public buildings, indirect lighting produced by bowl-shaped reflectors or opaque globes diffuses the light and prevents glare.

People today understand more clearly the importance of sunlight indoors. Sunlight is the strongest disinfectant, and only properly lighted rooms offer efficient working conditions. The modern light and airy house or apartment, with plenty of windows and well-placed electric lights, is a delightful contrast to the dark dens of the "good old days."

The first commercial lamp of 1.6 lumens per watt was made in 1881. The cellulose filament was introduced in 1893, giving 3.3 lumens per watt. The gem, or metallized-carbon filament lamp, made in 1905, gave 4 lumens per watt. The tantalum filament was introduced in 1906, giving 5 lumens per watt. The pressed-tungsten filament, giving 8 lumens per watt, was produced in 1907; and in 1911, the drawn-tungsten filament, Mazda, giving 10 lumens per watt. The gas-filled lamp of 20 lumens per watt was introduced in 1913.

Since that time to the present, electric lights are in use in (1) home-projection, (2) street traffic signals, (3) flashlight switchboards, (4) surgical-dental equipment, (5) industrial floodlighting, (6) aviation, (7) motion pictures, (8) television, (9) artificial daylight—the fluorescent light, (10) commercial signs, (11) on railways, and (12) for decoration.

LEARNING ACTIVITIES

1. Talks by members of class on lives of famous physicists
2. Talks on practical applications of principles studied
3. Reports on current developments
4. Demonstrations in class
5. Displays of posters and exhibits
6. Plays and vaudeville sketches (written by class members)
7. Outside physicists as speakers
8. Timely programs commemorating famous men of science
9. Moving pictures on subject under consideration
10. Excursions to community plants
11. Maintaining bulletin board for display of timely material
    Source of material: current magazines, newspapers, etc.
12. Keeping a scrapbook
13. Collecting charts and other exhibits
14. Writing essays

15. Developing projects
16. Developing chart to show jobs, pay, and training needed for work in electrical fields

Sources of Project Materials

1. In working out projects, students may write to various industrial firms, obtaining pamphlets, wall charts, samples of product.
2. Eliminate material which is not usable—some may be too advanced for high school students.
3. Selected pamphlet material may be good enough to use as a supplement to the text.

Evaluation:

1. Did we learn how to work together?
2. Was our science education related in our thinking to our knowledge of the past?
3. Have there been increased understanding and appreciation of man's progress?
4. Do we understand the scientific principles associated with modern lighting?

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PHYSICAL SCIENCE

Scope

A high percentage of students have no intention of taking college courses for scientific and technical careers for which the more formal courses in chemistry and physics are a preparation. Yet for these students continued science education beyond the tenth year is imperative. A physical science course of study which is adaptable to the needs of these students is necessary. What these students need is a course of study more advanced than that taught at the ninth and tenth grade level, yet not so formal as physics and chemistry. Some colleges accept such a course for entrance if the students do not intend to continue in science majors.

Sequence

The sequence that follows is neither all-inclusive nor mandatory. It should be employed as a suggested outline which can be of help in organizing a program of functional units. These should be taught over a period of *one or two years, during grades eleven and twelve.*

The course in physical science deals with the basic principles of physics, chemistry, geology, astronomy, and meteorology. These are taught and applied through familiar problems and experiences of everyday life. The students should acquire the behavior of applying these principles in their thinking about the solution of life problems through individual and group activities.

Although the outline suggests directed study guides, they should be prepared from a youth-centered point of view. If guide sheets are distributed without pupil participation in planning, much of the functional phase of learning will be lost. The method of approach and extent of pupil-planning will depend upon the nature of the pupils. The teacher should exert the utmost effort to develop a functional program

To achieve these objectives, the following unit sequence is presented:

UNIT I: How Can We Measure and Compare Things We Buy and Use?

UNIT II: Why Are Superstitions Disappearing?

UNIT III: How Do Changes in the Earth Affect My Environment?

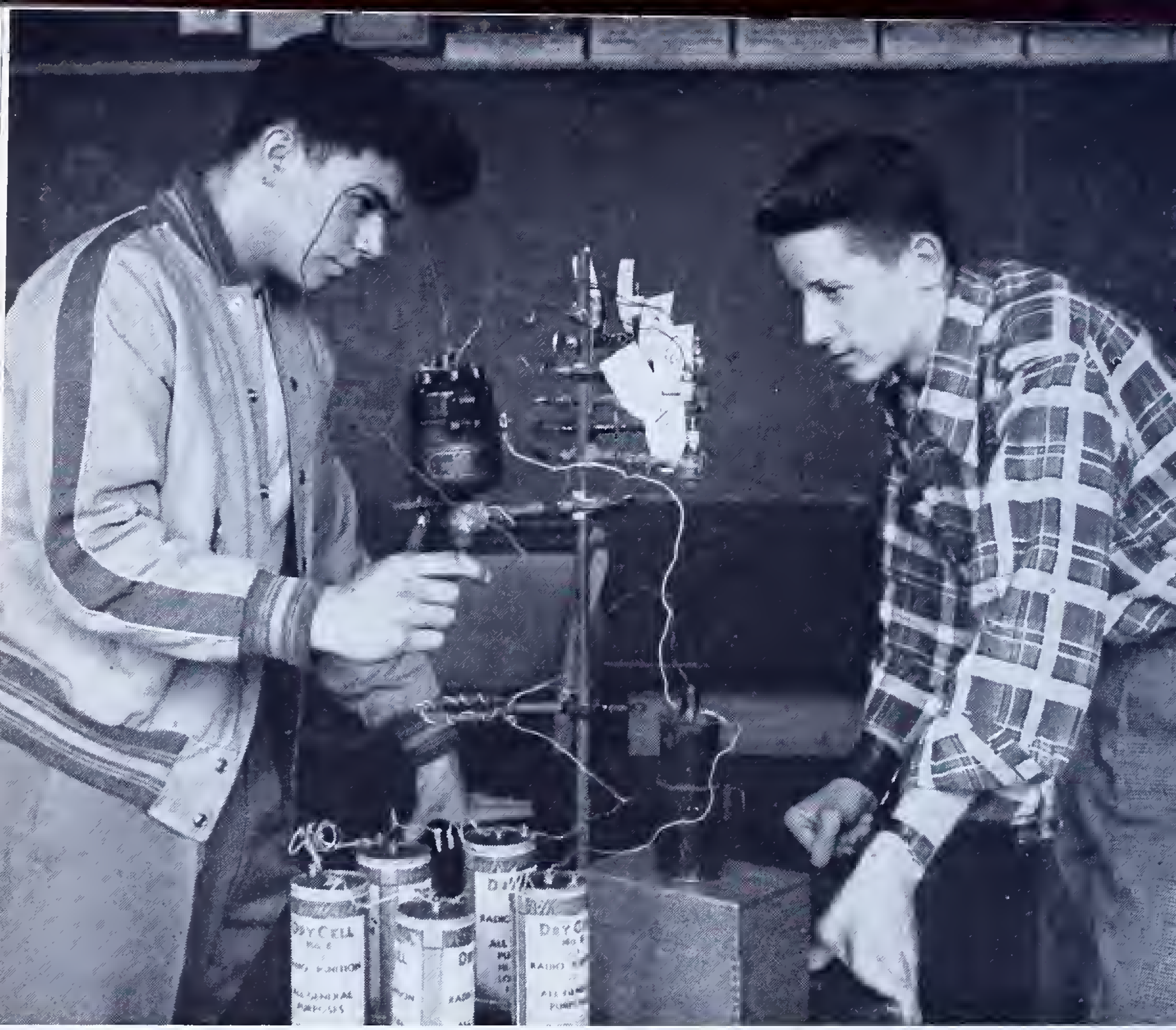
UNIT IV: How Can We Make Wise Purchases of Household Machinery?

UNIT V: How Is Electricity of Service to Me?

UNIT VI: What Should I Know About Automobiles?

UNIT VII: How Can We Guide Ourselves in Operating Our Automobiles Safely and Efficiently?

UNIT VIII: How Is Travel by Air, Water, and Rail Possible?



A MODEL IGNITION SYSTEM

Unit	IX:	How Can We Make Good Use of Light?
Unit	X:	What Is the Chemical and Physical Nature of Matter?
Unit	XI:	What Is Atomic Energy?
Unit	XII:	How Do We Use Air? How Does It Control Weather?
Unit	XIII:	How Can We Keep Warm and Comfortable?
Unit	XIV:	How Do We Use Acids, Bases, and Salts?
Unit	XV:	How Can We Avoid the Waste of Metals?
Unit	XVI:	How Does the Body Resemble a Chemical Processing Plant?
Unit	XVII:	What Can We Do With Synthetics and Plastics?
Unit	XVIII:	How Rich Is Pennsylvania In Mineral Resources?
Unit	XIX:	The Uses of Atomic Energy
Unit	XX:	What Should We Know About Cancer?

Introducing Units

Pupil-teacher planning is a necessary phase of effective functional education. (See Chapter IV.) In introducing the physical science units, provision should be made for this essential motivation. Such planning is especially advisable in physical science, for pupils already know a great deal about the problems.

Such planning may take the form of

1. Overview by the teacher
   Importance of the unit, etc.
2. Group discussion
   a. What do we know now?
      List on blackboard
   b. What do we need to find out?
      List on blackboard
   c. What work plan shall we use?
      List problems and committees on blackboard

The unit outlines are suggestive and flexible. They should be extended to meet specific problems of pupils and the needs of local communities, rural or urban. Variation in topics, problems, and activities will be desirable as circumstances vary.

Evaluation

Data on the evaluative procedures, which should terminate each unit, are suggested in Section 1, Chapter II, "Teaching Science by Units," and in Chapter IV, "Evaluation." A type of suggested student self-appraisal check list for Unit I is included at the end of that unit. Similar check lists for further units may be readily constructed.

Unit I

HOW CAN WE MEASURE AND COMPARE THINGS WE BUY AND USE?

1. *Overview by teacher*
2. *Groups planning discussion*
   a. What do we know now?
   b. What do we need to find out?
   c. What work plan shall we use?

Content	*Objectives*	*Activities*
1. What systems of measurement are most frequently employed? Why?	1. To understand the necessity for an accurate system of weights and measures	1. *By class or committees with reports* Look up metric and English tables of measurement
2. What tools are used to measure?	2. To compare the English and metric systems of measurement and the relative merits of each	2. *Readings and Reports* a. Origin of the English system of measurement
3. How can we measure accurately to within $\frac{1}{100}$ of an inch?	3. To develop skill in the use of the tools of measurement	b. Origin of the metric system of measurement
4. Does the weight on the label of a can tell us the exact weight of product purchased?	4. To appreciate the need for precision measurement in daily work activities	c. The legal adoption of the metric system by Congress
5. How may a weight given in a metric system be changed into the English system?	5. To stress the importance of reading labels on all goods purchased	d. The Bureau of Standards at Washington, D. C.
6. Why should we handle chemical reagents and reagent bottles with care?	6. To stress the importance of observing the quality and quantity purchased	e. Talk to class by the Sealer of Weights and Measures
7. How can we make use of density and specific gravity in determining purity of substances?	7. To learn how to transfer liquids from one container to another	3. *Laboratory*
8. How do we go about finding the correct answer to a question?	8. To stress the importance of proper handling of the chemical reagents and containers with emphasis upon safety	a. Measure the lengths of common objects in both the metric and English systems, making use of the common units
9. Other problems suggested by pupils	9. To review the mathematics necessary in understanding principles of physical science and knowing how to make good comparisons	b. Weigh some common objects in both the metric and English systems of weights

Objectives	*Activities*
10. To learn to make use of tables as reliable references	c. Determine the volume of containers in both the metric and English system
11. To learn to apply scientific thinking to the solution of problems	d. Determine the density of water
12. To learn the principles of the hydrometer and its application	e. Determine the specific gravity of a pure and an impure substance
13. To test Archimedes' Principle	f. Determine the specific gravity of a storage battery solution in order to learn the relationship between charge of battery and specific gravity
14. Other objectives suggested by pupils	g. Use vernier and micrometer calipers for precision measuring
	h. Measure quantity of contents in commercial brands of canned goods
	i. Work out some problems changing metric values to English values, and vice versa
	j. Investigate a problem employing method of scientific thinking
	4. *Culminating activities* Committee reports and displays
	5. *Other activities suggested by pupils*
	6. *Textbook and reference study*
	7. *Evaluation* a. See page 277 of this section and Chapter IV b. Administer a functional test c. Guide group self-evaluation
	8. *Use direct teaching where needed*

Student Self-Appraisal Check List for Unit I— How Can We Measure and Compare Things We Buy and Use?

The following example of a student self-appraisal exercise may be mimeographed and given to students. It should motivate self-evaluation and participation and provide an overview. Similar check lists for other units may readily be prepared. Items should be changed to suit local situations.

To the Student:

The following questions are for you to test yourself on what you are learning. Do not check *Yes* unless you know and know that you know.

1. Do you know how to use?

	Yes	*D.*	*No*
a. metric rule			
b. vernier caliper			
c. micrometer caliper			
d. balance			
e. graduated cylinder			

2. Do you know what kind of instruments and units are used to measure?

	Yes	*D.*	*No*		*Yes*	*D.*	*No*
a. length				g. electric current			
b. area				h. heat			
c. volume				i. speed of sound			
d. temperature				j. light intensity			
e. pressure				k. work			
f. speed				l. density			

3. Can you explain the meaning of the following words?

	Yes	*D.*	*No*		*Yes*	*D.*	*No*
a. acceleration				k. gram			
b. ampere				l. hydrometer			
c. barometer				m. hygrometer			
d. B.T.U.				n. kilowatt			
e. caliper				o. manometer			
f. calorimeter				p. pyrometer			
g. candle-power				q. thermometer			
h. centigrade				r. thermostat			
i. foot-pound				s. watt			
j. galvanometer				t. wave length			
				u. zero (absolute)			

4. Underline the word indicating the larger volume: (1) a gram or an ounce, (2) a liter or gallon, (3) a centimeter or an inch.

5. Do you know how to read the meters in your home?

6. What else did you learn in this unit?

7. What help did you give to the work of your class?

UNIT II

WHY ARE SUPERSTITIONS DISAPPEARING?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. What do horoscope readings tell us?	1. To develop an understanding for the basis of myths and superstitions	1. *By class or committees with reports*
2. What are the parts of the universe?	2. To appreciate the relationship between the stars and planets	a. Read about the myths concerning the more important constellations
3. What are the relationships of the parts of the universe to each other?	3. To understand that space is vast	b. Purchase a horoscope booklet and study the basis for the predictions offered in it
4. How do the parts of the universe move?	4. To understand that the earth is very old	c. Reports on scientists who have contributed to a better understanding of the universe
5. How distant are the sun and stars from the earth?	5. To understand that changes in seasons and differences in weather and climate depend largely upon the relation of the earth to the sun	2. *Pupil projects*
6. How does the sun affect our daily living?	6. To appreciate the contributions of scientists who have helped us understand the relation of heavenly bodies to our way of living	a. Demonstrate solar and lunar eclipses
7. Why are nights longer and days shorter during the winter season as compared to the summer season?	7. To develop astronomy as a hobby	b. Demonstrate phases of the moon
8. Is life possible on planets other than the earth?	8. To understand the meaning of gravitational and centrifugal forces	c. Demonstrate centripetal and centrifugal forces
9. How do we measure distances between heavenly bodies?	9. To learn to distinguish between stars, planets, and asteroids	d. Perform an experiment involving gravitation
10. What are comets, meteors, and satellites?	10. To understand the causes for seasons and day and night	e. Observe the spectrum of the sun
11. How have religious rites been built around heavenly bodies?	11. To learn to read star charts	f. Survey the reliability of horoscopes
12. Why do people believe in certain superstitions?		g. Study the pattern and motion of stars and planets
		h. Study the basis for such superstitions as "It will rain if you kill a toad" or "You will develop warts if you handle a toad" or other similar superstitions
		i. Visit a planetarium

Content	*Objectives*	*Activities*
13. Other problems suggested by pupils	12. To establish an understanding of the order of the universe 13. To learn about jobs involving astronomical, gravitational and centrifugal data 14. Other objectives suggested by pupils	j. Visit a museum to observe meteorites k. Observe the stars through a telescope l. Construct a simple telescope m. Other projects of pupils 3. *Culminating activities* Committee reports and displays 4. *Other activities suggested by pupils* 5. *Textbook and reference study* 6. *Evaluation* (See p. 277.) 7. *Use direct teaching where needed*

UNIT III

HOW DO CHANGES IN THE EARTH AFFECT MY ENVIRONMENT?

Overview by teacher and planning with pupils

Content	*Objectives*
1. How does the appearance of the earth today compare with its appearance at the time of its origin?	1. To learn to understand the significance of a theory as differentiated from a scientific fact
2. How do the forces causing changes of the earth today compare with the forces during its origin?	2. To understand that the earth at its beginning was different from the earth of today
3. How are volcanoes constructive as well as destructive?	3. To understand that interior and exterior forces are constantly bringing about changes on the earth's surface that may be constructive as well as destructive
4. What building problems do earthquakes present?	4. To understand that the changes in the earth's structure take millions of years
5. What changes on the earth's surface are produced by erosion, diastrophism, and glaciers?	5. To learn that man can limit the destructiveness of some of the forces bringing about changes of the earth
6. What conservation methods can man employ to preserve or reclaim the soil?	6. To develop a critical attitude for determining values
7. How much fertile soil is available to us?	7. Other objectives suggested by pupils
8. Other problems suggested by pupils	

Activities

1. *By class or committees with reports*
   a. Report on the Tidal Theory of the Earth
   b. Read an account of the forces acting on the earth during its formation
   c. Report on the formation of the atmosphere and oceans
   d. Report on the scientists' methods of determining the age of the earth
   e. Read an account of the activity of some of the most destructive volcanoes, namely, Vesuvius, Krakatao, Mount Pelée, and Parícutin
   f. Report on the San Francisco Earthquake of 1906
   g. Read an account of the ice ages and summarize in a report to the class
   h. Write a report on the men who study volcanoes and earthquakes
2. *Projects*
   a. Make a critical survey of the medicinal value of mineral waters originating in the form of hot springs and geysers
   b. Take a field trip to observe the effects of erosion and what controls are being employed to conserve our soil
   c. Talk or interview by agent of the Department of Agriculture
   d. Study several methods of home construction
3. *Culminating Activities*
   a. Committee reports and displays
   b. Other activities suggested by pupils
4. *Textbook and reference study*
5. *Evaluation* (See p. 277)
6. *Use direct teaching where needed*

Unit IV

HOW CAN WE MAKE WISE PURCHASES OF HOUSEHOLD MACHINERY?

Overview by teacher and planning with pupils

Content	Objectives	Activities
Vacuum Cleaner 1. What is the meaning of the word *vacuum* in connection with the cleaner? 2. How does a vacuum cleaner operate? 3. What are the merits of the three main types of vacuum cleaners on the market today? 4. How do the cleaners differ in operation? 5. What must we learn about motors that operate vacuum cleaners? 6. Is a rebuilt cleaner a practical economy for the consumer? *The Refrigerator* 1. How does a mechanical refrigerator get cold? 2. What other methods are employed for preserving foods besides the use of refrigeration? *Other problems suggested by pupils*	1. To discover the principles of operation of a vacuum cleaner 2. To learn how to make a comparative study for wise purchase of equipment 3. To understand that air has weight and therefore exerts a pressure 4. To learn to understand the principles of magnetism 5. To learn to understand the principle of an electric motor 6. To learn the construction and use of barometers 7. To learn how to determine the density of air 8. To understand the application of Boyle's law 9. To understand the operation of a siphon 10. To understand the principle of compression 11. To understand the principles of cooling through evaporation 12. To learn how to measure gas pressure 13. Other objectives suggested by pupils	1. *By class or committees with reports* a. Make a poster diagram of a vacuum cleaner, showing parts and the path the air takes when traveling through the machine b. Look up the ratings of vacuum machines in one of the consumer bulletins and make a list of the factors that were employed in making such ratings c. Make a comparison of any two vacuum cleaners now on the market as to original cost, cleaning ability, ease of operation, probable wear on rugs, and possible lifetime of machine d. Demonstrate that air has weight e. Construct and explain the use of a barometer f. Examine simple electrical motors and make a diagram of one labelling the four parts of a motor and tracing the current g. Demonstrate that the earth is a magnet 2. *Laboratory Experiences* a. What pressure does the atmosphere exert?

Activities

- b. The principle and operation of a siphon
- c. Determine the approximate density of air in the room
- d. Demonstrate that the volume of a gas varies with the pressure exerted upon it
- e. Study the characteristics of magnets
- f. Study the relation of electromagnets to magnets
- g. The electric motor
- h. The refrigerator

3. *Projects*
   - a. Make a comparison of the advantages and disadvantages of ice refrigerators and mechanical refrigerators
   - b. Examine an electric type and a gas type of mechanical refrigerator and make labelled diagrams showing how ice forms
   - c. Look up the ratings of mechanical refrigerators in one of the consumer bulletins and make a list of the factors employed in making such ratings
   - d. Make a list of the types of refrigerators sold in your community and decide which make you would buy. Justify your choice
4. *Experiments*
   - a. The simple air pump
   - b. Measuring gas pressure with a manometer
   - c. Cooling effect of ice and ice water
   - d. Cooling through evaporation
   - e. Other projects suggested by pupils
5. *Culminating activities*
   - a. Committee reports and displays
   - b. Other activities suggested by pupils
6. *Textbook and reference study*
7. *Evaluation* (See p. 277.)
8. *Use direct teaching where needed*

Unit V

HOW IS ELECTRICITY OF SERVICE TO ME?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. What great discoveries made electricity available to us?	1. To appreciate the value of discoveries that have made electricity available to us	1. *By class or committees with reports* a. The contributions to society made by Edison, Steinmetz, Faraday, Franklin, Bell, Morse, Marconi, and any other great electrical inventor
2. How is electricity produced?	2. To gain a general understanding of the problems involved in producing and distributing current electricity	
3. What does it cost to transmit electricity to our homes?		b. How electricity has made the world smaller
4. How would you connect several cells if you wanted more voltage?	3. To gain a general understanding of the control and use of moving electrons	c. How electricity has changed the habits of living
5. How would you connect cells if each appliance in the circuit takes a different amount of current`	4. To study the factors that determine the voltage and current that a cell or battery can deliver; circuits in series and in parallel	d. The transatlantic telephone e. Teletype system f. Visit the local power distributing plant
6. What changes could you make in a strand of Christmas tree lamps to make them last longer?	5. To study the factors upon which resistance depends and their relationships	g. Visit the local telephone exchange. h. The parts Hero of Alexandria, Savery, Newcomer, Watt, Stephenson, and Fulton played in the development of steam as a source of power
7. What factors determine the voltage and amperage a cell can deliver?	6. To understand the usage of Ohm's law	
8. What is the relationship between volts, amperes, and ohms? How can you determine one of these if you know the other two?	7. To know how to measure resistance	i. Make a list of such questions as you think important to consider when making a purchase of a household appliance
9. What factors influence resistance and how would you measure it?	8. To make the label on home electrical appliances meaningful	j. Build a simple radio receiver
10. What principles of current electricity does an electrician use in wiring a house for electrical outlets?	9. To gain sufficient knowledge of electrical circuits so as to know and practice safety rules in the home, automobile, and shop	k. Visit a broadcasting station l. Visit a telecasting station m. The present status of television

Content	*Objectives*	*Activities*
11. How would you connect house lights? Bell? Telephone? Telegraph instruments?	10. To learn how and why one should care for a storage battery	n. Transatlantic radio communication
12. How do we use electric current to produce light and heat?	11. To gain an understanding of the necessity for care when near high voltage transmission lines and transformers	o. The amateur's place in the development of radio
13. How should one care for a storage battery?		2. *Laboratory Experiments*
	12. To gain an understanding of the operation of some much-used appliances in the home	a. The construction and operation of a dry cell
14. How much does it cost to operate the various home electrical appliances?		b. The construction and action of a simple storage cell
	13. To study the cost of operating the appliances so that we may become better consumers	c. The measurement of electricity
15. What should we know about the construction and operation of such common household devices as irons, percolators, stoves, toasters, etc., in order to make us wise buyers and users?		d. The study of parallel and series circuits
	14. To gain an intelligent understanding of the elementary principles of radio and television	e. The electric doorbell
		f. Cost of operating electrical appliances
16. How does a telephone work?	15. To study some of the ways we employ moving electrons to work for us and safeguard our valuable possessions	3. *Culminating activities*
17. How are radio waves produced and received?		a. Committee reports and displays
		b. Other activities suggested by pupils
18. How do sounds change the shape of radio waves?	16. To recognize that modern communication has made our world small	4. *Textbook and reference study*
19. How does a radio work?	17. To learn about jobs in this area of work	5. *Evaluation* (See p. 277.)
20. How are light waves used to control sound and mechanical devices?	18. Other objectives suggested by pupils	6. *Use direct teaching where needed*
21. Other problems suggested by pupils		

Unit VI

WHAT SHOULD I KNOW ABOUT AUTOMOBILES?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. How does the electrical system in the automobile function? 2. How does the automobile engine develop power and transmit the power to the wheels? 3. How does the internal combustion engine receive and regulate the fuel supply? 4. How are automobile engines cooled? 5. What problems in steering result in the operation of an automobile? 6. How do we control the automobile? 7. How can we guide ourselves in operating our automobile safely and efficiently? 8. Other problems suggested by pupils	1. To gain an understanding of how electricity is transmitted from the battery to the combustion chamber 2. To gain an understanding of the principle of internal combustion 3. To learn how more uniform power is developed 4. To gain an understanding of the principles of power transmission 5. To understand the use of Bernoulli's principle as applied to the carburetor 6. To learn the relationship between power and compression ratio 7. To become acquainted with the principle of the thermostat 8. To gain an understanding of how heat is absorbed and carried away 9. To learn how to control an automobile 10. To learn how defects in the steering gear may be detected 11. To understand the application of Pascal's principle 12. To learn how to operate an automobile safely and efficiently 13. To learn about jobs in automotive services	1. *By class or committees with reports* a. Make a trip to a garage and identify the differential, clutch, timing gears, camshaft, valve assembly, L-head and overhead valve motors, fuel pump, distributor, and other automobile parts in the unit b. Through committee action investigate recent changes in automobiles c. Make a collection of automobile pictures that will show the transition in design from beginning of automobile production to the present day d. Demonstration of explosion of gas and air mixture e. Demonstration of Bernoulli's principle f. Demonstration of Pascal's law g. Through group activity seek answers to the series of questions found in *User's Guide* published by General Motors 2. *Laboratory Experiments* a. Useful and useless expansion b. To find the relation between the heat lost by a hot body and that gained by a cold body when the two are brought into contact

DEMONSTRATION OF CARBURETOR ACTION

Activities

c. To study three methods of heat transmission
d. Finding how much a given material expands
e. Comparing the heating effect of equal weights of steam and water at 100° C
f. Observing the phenomena of boiling
g. What antifreeze is a good buy?
h. Other projects suggested by pupils

3. *Culminating activities*
   a. Committee reports and displays
   b. Other activities suggested by pupils
4. *Textbook and reference study*
5. *Evaluation* (See p. 277.)
6. *Use direct teaching where needed*

Unit VII

HOW CAN WE GUIDE OURSELVES IN OPERATING OUR AUTOMOBILES SAFELY AND EFFICIENTLY?

To be carried out through organized committee investigations and reports

Specific Objective: To learn how to operate an automobile safely and e ficiently

1. What pressure will the oil gauge show when oil is thin?
2. What does it indicate if pressure is more than normal?
3. What will temperature gauge show when there in a frozen radiator?
4. Can cold water be added to radiator at any time?
5. What should ammeter show when ignition is turned on?
6. Is it necessary to check the battery when the ammeter is normal?
7. What are beam indicators?
8. What are lubricants?
9. Can all parts of a car be lubricated with the same grade of oil? Why?
10. What is the danger of grease on brake linings?
11. When should cars be lubricated?
12. Which parts require lubricating?
13. Why does oil have to be changed at intervals?
14. How much oil does a car use between crankcase changes?
15. What kind of oil should be used for different seasons?
16. How can you tell which is light or heavy oil?
17. When should spark plugs be checked?
18. Should adjustments be made on the carburetor?
19. How often should an air cleaner be cleaned?
20. What causes an engine to *ping*?
21. What care does a radiator need?
22. Can antifreeze solutions be saved?
23. When are thermostats the more important?
24. How should the clutch pedal be adjusted?
25. How should the brake pedal be adjusted?
26. How can you tell when the steering gear needs adjustment?
27. How can one secure better traction in tires?
28. What are dangers of underinflation?
29. What are dangers of overinflation?
30. What does speed have to do with tire wear?
31. How can underinflation be detected?
32. Should your foot be on the clutch when starting? When driving?
33. What are dangers of choking a car?
34. What do we mean by "slip the clutch"?
35. If your car is on ice, what is easiest way to start?
36. If you double your speed how soon can you stop?
37. What should you do in case of a skid?
38. What is the easiest way of parking in a small place?
39. What are mileage tests?
40. Why and when are they made?
41. Should the tank be completely filled when buying gas?
42. When should you shift gears on a hill?

43. How should you drive through water?
44. Who knows the most about driving?
45. How can you avoid accidents?
46. How do you remove spots from upholstering?
47. What are the six instruments found on the panels of most recently manufactured cars?
48. How should tires be changed to give even wear?
49. What do octagonal, round, and diamond-shaped highway signs mean?
50. How can you bring back a new finish to a dirty exterior?
51. When should the motor oil be changed?
52. Tell how you start a car, operate in traffic, on hills, on slippery pavement, and make stops and starts.
53. How would you correct the following: (1) black exhaust smoke; (2) irregular or unsmooth engine timing; (3) shimmy; (4) brakes that do not hold; (5) clogged radiator; (6) overcharging generator; (7) knocking motor; (8) short circuit; (9) cold motor; (10) flat tire; (11) continuously sounding horn; (12) dead battery?
54. How much does an auto mechanic earn? A gas station attendant? A car salesman?
55. Prepare a chart showing jobs, pay, etc., in automotive industries.

UNIT VIII

HOW IS TRAVEL BY AIR, WATER, AND RAIL POSSIBLE?

Overview by teacher and planning with pupils

Content	Objectives	Activities
1. How did man travel before the invention of the steam engine and internal combustion engine?	1. To gain an appreciation of modern methods of transportation	1. *By class or committees with reports* a. Make a survey of new trends in railroad trains b. Make a survey of new trends in aircraft c. How do the modes of transportation compare in safety? d. Report on how a pilot directs his path of flight e. Study the design of some model planes and show how they differ in application of principles f. Read the story of Santos-Dumont and Count Zeppelin g. Write a report on Maxim's experiments with kites h. Demonstration of the principles of the turbine i. Study time table charts j. Talk by an aviator k. Talk by a station agent
2. What inventions of steam action made our modern steam locomotive possible?	2. To appreciate the contributions of scientists toward the development of the steam locomotive	
3. To what is the power of steam due?	3. To learn to understand the principles of expansion	
4. How is the power of steam transmitted to the wheels of an engine or propeller of a ship?	4. To gain an understanding of how reciprocating motion is converted to rotary motion	
5. How is a ship supported by water?	5. To gain an understanding of the principle of the steam engine	
6. What is a steam turbine and how does it work in its simplest form?	6. To learn how a diesel engine operates	
7. Why is the diesel engine supplanting the steam engine in transportation vehicles?	7. To recognize the pioneering spirit of scientists who made flight by air possible	
8. What pioneering inventions made transportation by air possible?	8. To understand the application of Bernoulli's principle to the wing of a plane	
9. Why does an airplane rise into the air?	9. To gain an understanding of how a plane is controlled in flight	2. *Laboratory Experiments* a. How does a simple steam engine operate and transmit power?
10. How is an airplane guided in flight?	10. To gain an understanding of how the jet engine and mechanical engine provide power for the plane	b. Buoyancy c. Other projects of the pupils
11. What is the source of power for the airplane?	11. To learn how to use a transportation time table	3. *Culminating Activities* a. Committee reports and displays b. Other activities suggested by pupils
12. How can I travel with the least loss of time?	12. To learn about jobs in transportation and aviation	4. *Textbook and reference study* 5. *Evaluation* (See p. 277.)
13. Other problems suggested by pupils	13. Other objectives suggested by pupils	6. *Use direct teaching where needed*

UNIT IX

HOW CAN WE MAKE GOOD USE OF LIGHT?

Overview by teacher and planning with pupils

Content

1. What makes it possible for us to see?
2. How does poor home lighting affect the physical well-being of the individual?
3. What is the basis for good lighting?
4. How can we become efficient consumers of light?
5. How can we use light as a hobby?
6. What are some common eye defects and how can they be corrected?
7. What light is kind to our eyes?
8. What causes the colors in our clothing?
9. Why are some colors more pleasing than others?
10. Other problems suggested by pupils

Objectives

1. To gain a useful knowledge of the construction and operation of the human eye to the end that sight may be conserved
2. To become aware of the effect of poor home lighting on the physical well-being of an individual
3. To gain a knowledge of intensity of light and how to control illumination properly
4. To learn how to be an efficient consumer of light
5. To gain an understanding of refraction of light through lenses and its uses in a camera
6. To develop an interest in taking pictures
7. To gain a useful knowledge of the cause of color formation and its application in daily living
8. To gain a useful understanding of the laws of reflection
9. To gain some understanding of the effect of color upon the emotional nature of man
10. To learn about jobs in lighting, etc.
11. Other objectives suggested by pupils

Activities

1. *By class or committees with reports*
   a. Draw a plan of your living room, showing the position of each piece of furniture, each light, and the color and kind of material on the walls, floor, and ceiling
   b. Draw a revised floor plan of the same room showing the changes that you think are necessary to produce good lighting
   c. Make committee evaluations of several of these plans
   d. Take pictures and develop negatives and pictures
   e. Make a refracting telescope
   f. Demonstrate optical illusion
   g. Make and use a pinhole camera
   h. Report on color printing and color photography
   i. Demonstration of direct, semi-direct, and indirect lighting
   j. Demonstration of fluorescent lighting
   k. Talk by an oculist
   l. Conducting of eye tests
2. *Laboratory experiences*
   a. To find the candle power of a lamp
   b. Reflection of light from a plane mirror

Activities

   c. Refraction of light through glass plate and spherical lenses
   d. Images formed by plane and spherical mirrors
   e. Other projects of the pupils
3. *Culminating activities*
   a. Committee reports and displays
   b. Other activities suggested by pupils
4. *Textbook and reference study*
5. *Evaluation* (See p. 277.)
6. *Use direct teaching where needed*

Unit X

WHAT IS THE CHEMICAL AND PHYSICAL NATURE OF MATTER?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. How does science classify matter both physically and chemically? 2. How can physical changes and chemical changes take place in matter? 3. How does science show the relationship between matter and energy? 4. How does science use a shorthand in showing the composition of matter? 5. How does science use a shorthand in showing chemical change? 6. How does chemical energy differ from atomic energy? 7. Other problems suggested by pupils	1. To learn how to differentiate between an element, a compound, and a mixture 2. To learn that matter exists in a form of a liquid, a solid, and a gas 3. To learn that elements are made up of tiny particles of matter called atoms 4. To understand how atoms combine to form molecules 5. To learn that chemical change is the result of a combination of atoms or an exchange of atoms between compounds 6. To learn what a formula represents and how to read a chemical formula 7. To learn what a chemical equation represents and how to read it 8. To learn that chemical changes are either exothermie or endothermic 9. To learn that all matter is fundamentally of an electrical nature 10. To learn that the source of atomie energy is in the nucleus of the atom whereas chemical energy is in the orbits of the atoms	1. *By class or committees with reports* a. Prepare a chart contrasting the symbols used by alchemists and those used by modern chemists b. Make a list of common substances and classify them as elements, compounds, mixtures e. Perform a simple experiment that illustrates statie electricity d. By model or diagram show how the arrangement of electrons, protons, and neutrons in an atom resembles the solar system e. Report on how some of the elements derived their names f. Report on Dalton's atomic theory g. Find out which of the elements were known to ancient man h. Demonstration of how elements and compounds differ i. Demonstration of molecular motion j. Demonstration of the electrolysis of water 2. *Laboratory experiments* a. Compounds and mixtures b. Physical and chemical changes

Content	*Objectives*	*Activities*
	11. To learn the meaning and use of atomic weights	c. How heat, electricity, light, and mechanical motion may produce a chemical change
	12. To learn what isotopes are	d. The law of conservation of matter
	13. To gain an understanding that the minute particle of matter patterns our solar system	e. Four types of chemical reaction f. Other projects suggested by pupils
	14. To learn to distinguish between a metal and a nonmetal	3. *Culminating activities* a. Committee reports and displays
	15. To learn that a chemical change does not destroy matter	b. Other activities suggested by pupils
	16. To learn uses of compounds and mixtures	4. *Textbook and reference study* 5. *Evaluation* (See p. 277.)
	17. Other objectives suggested by pupils	6. *Use direct teaching where needed*

Unit XI

WHAT IS ATOMIC ENERGY?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. How do we differentiate the atoms, one from the other?	1. To understand how scientists differentiate one atom from another	*By class or committees with reports* 1. *Reading* a. Helpful information on available literature, filmstrips, films, etc., is found in a supplement to *School Life*, Vol. 31, March 1949, entitled "Atomic Energy, Here to Stay," published by the Federal Security Agency, Office of Education, in cooperation with the United States Atomic Energy Commission
2. How do scientists account for the formation of isotopes?	2. To learn that atoms of the same substance may have different masses	
3. How has transmutation been accomplished through atom smashing?	3. To learn that changing of one element into another is an accomplished fact	
4. How do we differentiate between mass and energy?	4. To learn that mass and energy are the same but in different form	
5. How much atomic energy does a pound of matter possess?	5. To understand better the vast amount of nuclear energy that one can possibly acquire from a pound of substance	b. *Adventures Inside the Atom*, produced by General Electric Company
6. How has atomic energy been released through chain reaction?	6. To gain an understanding of how nuclear energy is released	c. *Operation Atomic Vision*, published by the National Education Association, 1201 Sixteenth Street N. W., Washington, D. C.
7. What is the difference between the fission bomb and the fusion bomb?	7. To understand better the difference between a fission and a fusion bomb	
8. How can atomic energy contribute to the welfare of man?	8. To develop an understanding of the tremendous cost of producing atomic energy	d. *The Effects of Atomic Weapons*, Supt. of Documents, Washington, D. C.
9. Is atomic energy practical economically?	9. To acquire a better understanding of the destructiveness of atomic energy	2. *Show filmstrips*
10. What effect would the dropping of an atomic bomb on certain strategic areas have on the economy of a nation?	10. To develop a critical attitude toward the proposed uses of nuclear energy in the field of power, heat, and medical research (See Unit XIX, p. 310.)	a. Madame Curie and her work with radium[1] b. Show atomic bomb filmstrips[2]

Content	*Objectives*	*Activities*
11. What are the political implications of atomic energy? 12. What are the social, cultural, and ethical implications of atomic energy? 13. Other problems suggested by pupils	11. To understand better the impact of nuclear energy upon world economics 12. To learn about jobs in electronics 13. To develop an appreciation of the fact that such developments as atomic energy come about because of the contribution of scientists from many countries of the world 14. To learn what to do if an atomic bomb is dropped 15. Other objectives suggested by pupils	c. Study the Army Signal Corps film "Tale of Two Cities" to get information on the destructive effect of atomic warfare 3. *Projects* a. Defense talk by local Civilian Defense Director b. Prepare brief biographies of Fermi, Urey, Bohr, Oppenheimer, Compton, Laurence, etc. c. Prepare diagram for bulletin board display to show how atomic energy is released; time, and radius of dangerous areas d. Make a map of the world showing deposits of raw materials from which atomic energy is produced e. Prepare an exhibit to demonstrate control of atomic energy f. Report on the necessity of international control of atomic energy. Discuss obstacles g. Report on the possible use of atomic energy for transportation h. Report on the use of radioactive isotopes in industrial research i. Report on the use of radioactive isotopes to increase agricultural production j. Report on the use of radioactive isotopes in medical research

Activities

k. Report on the attempt at international control of atomic energy in the UN Assembly

l. Build models to illustrate the basic information about atomic energy, such as pile reactors, radiation detection devices, protecting shields, etc.

m. Compare the cost of producing atomic energy with that of mining coal or producing other fuels

n. Compare the source of energy in the sun with that of the atomic bomb and hydrogen bomb

o. Report on what to do if an atomic bomb explodes

p. Other projects suggested by pupils

4. *Culminating activities*
   a. Committee reports and displays
   b. Other activities suggested by pupils
5. *Textbook and reference study*
6. *Evaluation* (See p. 277, and Student Self-Appraisal Check List, p. 280.)
7. *Use direct teaching where needed*

[1] Metropolitan Life Insurance Co.
[2] Produced by the Armed Forces Photo Company, 2001 O Street N.W., Washington, D. C.

Unit XII

HOW DO WE USE AIR? HOW DOES IT CONTROL WEATHER?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. What is the atmosphere made of and how much of it do we have?	1. To understand how we depend upon the elements of the atmosphere	1. *By class or committees with reports* a. Report of air conditions at various altitudes
2. How is oxygen a life-giver?	2. To learn about the chemical behavior of elements	b. Report on stratosphere flights
3. What problems does oxygen create for us and what problems does it solve for us?	3. To learn to understand the principle of oxidation	c. Demonstration of the use of liquid air
4. How does oxygen provide us with energy?	4. To understand how we utilize the elements of nature	d. Report on the use of ozone in water purification
5. Without carbon dioxide could we survive?	5. To gain an understanding of the process of photosynthesis	e. Bring some dry ice into class and discuss its value to transportation
6. How do industries make use of carbon dioxide?	6. To learn how weather forecasts are made	f. Draw a chart showing how air maintains a near balance of oxygen, carbon dioxide and nitrogen
7. How does nitrogen serve us in agriculture, medicine, and household usage?	7. To learn how the Weather Bureau functions	g. Report on how we can avoid dangers of high concentration of carbon dioxide
8. Why are nitrogen compounds considered a dangerous chemical family?	8. To realize how man has adapted himself to various weather conditions	h. Demonstrate the process of photosynthesis
9. Where do clouds come from?	9. To do away with incorrect weather superstitions	i. Demonstrate how carbon dioxide is responsible to some extent for erosion of rocks
10. Does the appearance of a cloud help man predict the weather?	10. To understand what causes storms	
11. Why do clouds move?	11. To learn how to analyze a weather map	j. Interview several farmers regarding (1) the use of nitrogen compounds in improving their soils and (2) about agriculture as an occupation
12. How can we use instruments to make possible prediction of weather?	12. To appreciate the value of weather reports	

Content	*Objectives*
13. How do air masses and fronts affect weather?	13. To learn how to regulate humidity in the home
14. Can you analyze a weather map and predict weather?	14. To realize the importance of purity of air and proper humidity of air in the home for the benefit of one's health
15. Why do different areas have different climates?	15. To learn about jobs in weather prediction
16. Can we control the weather?	16. Other objectives suggested by pupils
17. How can weather reports be of service to man in everyday living?	
18. Other problems suggested by pupils	

Activities

k. Report on nature's way of returning nitrogen to the soil

l. Demonstration of the arc process for returning atmospheric nitrogen to the soil

m. Make a report of the TVA, emphasizing the program, purpose, value to agriculture, value to defense, and value in checking floods

n. Investigate the use of inert elements found in the atmosphere

o. Report on the air pollution problems in your community, and what is being done to maintain a pure supply of air in your living areas

p. Demonstrate by diagram or otherwise how a healthful supply of air can be provided for the home

q. Through the use of instruments and weather maps, record climatic conditions in your area and see if you can predict the weather

r. Devise a way of determining humidity in your home, and show how you may increase or decrease humidity

s. Devise a way of demonstrating to the class the cooling effect produced by evaporation

t. Collect pictures showing cloud formations

u. Survey the reliability of weather beliefs

v. Listen to radio weather reports and check the results

w. Take a trip to the sewage disposal plant and show how oxidation operates

2. *Laboratory experiments*
   a. Composition of air
   b. The preparation and properties of oxygen
   c. Oxidation
   d. The preparation and properties of carbon dioxide
   e. The preparation and properties of nitrogen
   f. Determination of dew point and its relation to humidity
   g. The preparation and study of some nitrogen compounds
   h. Other projects suggested by pupils
3. *Culminating activities*
   a. Committee reports and displays
   b. Other activities suggested by pupils
4. *Textbook and reference study*
5. *Evaluation* (See p. 277.)
6. *Use direct teaching where needed*

How Do We Use the Air? How Does it Control Weather?

Student Self-Appraisal Check List for Unit XII

1. *Useful Knowledge*

	Yes	D.	No
a. Do you know what the air is composed of?			
b. Do you understand what humidity is?			
c. Can you explain how air is necessary for plant and animal growth?			
d. Do you know what education you would need to be a weather man?			
e. Can you explain why clouds do not fall?			
f. Do you know what the average amount of precipitation is for your community? Average temperature?			
g. Can you explain what causes wind? storms?			
h. Can you recognize the different kinds of clouds?			
i. Can you read a weather map?			
j. Can you read a thermometer? barometer? hygrometer?			

2. *Vocabulary*

Can you explain and use the following words or terms?

	Yes	D.	No
a. altitude			
b. aneroid			
e. condensation			
d. dew point			
e. evaporation			

	Yes	D.	No
f. relative humidity			
g. temperature			
h. water table			
i. weathering			
j. vacuum			

3. *Principles and Laws*

Can you name four scientific principles or laws which explain any of the following daily activities or phenomena?

rain, clouds, hail, 1. ______________ 3. ______________
humidity, evaporation 2. ______________ 4. ______________

4. *Daily Activities and Phenomena*

Can you name four uses for any of the following scientific phenomena?

air pressure, wind, condensation, 1. ______________ 3. ______________
evaporation, ventilation, vacuum 2. ______________ 4. ______________

5. *Can you erect apparatus and demonstrate—*

	Yes	D.	No
a. That water vapor condenses in the air?			
b. That air has weight?			
c. That air has pressure?			
d. That rain can be predicted?			
e. That warm air rises?			

6. What else did you learn in this unit?

7. What help did you give to what your class did?

Unit XIII

HOW CAN WE KEEP WARM AND COMFORTABLE?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. Why is fire a necessity to us?	1. To understand how we depend upon fire for our comfort	1. *By class or committees with reports*
2. How can fires be started, desirable and undesirable?	2. To appreciate that man has been capable of adapting himself to various climates through the use of fire	a. Report on the use of fire 500 years ago as compared to the use today
3. How can we control unwanted fires?	3. To understand better what causes fires	b. Report on the mythical explanation for the origin of fire
4. How do wood, coal, coke, gases, and liquid fuels serve us?	4. To realize the tremendous yearly damage due to unwanted fires	c. Report on the most damaging fire observed
5. How has an abundance of fuels contributed to world development?	5. To learn how to prevent undesirable fires	d. Interview a fire insurance representative and report on the annual losses due to fires caused by negligence
6. What kind of heating plant is most suitable to one's use?	6. To gain a better understanding of the heating value of wood, coal, coke, gases, and liquid fuels	e. Interview a fire insurance representative and report on the variable costs of fire insurance and how a saving can be made through better fire protection
7. What should I know about the fuel I buy?	7. To learn to use efficiently and safely the different types of fuel	f. Survey the home area to determine the possibility of fire hazards through spontaneous combustion and otherwise
8. What clothing should I wear?	8. To gain an understanding of the physical and chemical principles related to the burning of fuels	g. Acquire and learn to handle the different types of fire extinguishers
9. How can I make a wise purchase of clothing?	9. To learn to appreciate the contribution of fuels to industrial development	h. Visit the fire company in your area and study the facilities available
10. Other problems suggested by pupils	10. To become acquainted with the various types of home heating plants	i. Make a study of the fire alarm system in your living area
	11. To gain an understanding of the principles involved in the operation of each type of heating plant	j. Make a report to the class telling why forest conservation is a very

Unit XIII—Continued

HOW CAN WE KEEP WARM AND COMFORTABLE?—Continued

Content	*Objectives*	*Activities*
	12. To gain a better understanding of how to make a wise purchase of fuel 13. To learn to wear proper clothing seasonally 14. To learn to recognize types of clothing materials 15. To learn how to make a wise purchase of clothing 16. Other objectives suggested by pupils	important subject in our life today k. Investigate and make a report on the kind of wood and various prices of wood that dealers in firewood have for sale l. Visit a coal dealer and observe the various kinds of coal he sells, the price he asks for each, and the fuel value of a ton of coal m. Make a comparative study of the costs and fuel values of each type of fuel n. Make a collection of the various common products made from coal and coal tar and arrange these materials in a suitable display o. Make a collection of the allotropic forms of carbon and explain to the class the existing differences and their uses p. Make a report to the class on the two main theories for the origin of petroleum g. Demonstration to show that smoke is wasted fuel r. Demonstration to show how charcoal may remove impurities s. Demonstrate the preparation of acetylene and show how an increased amount of oxygen improves combustion and increases the heat value of the gas

Activities

t. Demonstrate the operation of the different types of fire extinguishers
u. If possible make a visit to a home that employs some modern method of heating, such as radiant heating
v. With the aid of consumer reports and government publications learn what factors are employed in determining quality of textiles

2. *Experiments*
   a. Does a substance gain or lose weight during the burning process?
   b. Destructive distillation of wood and coal
   e. Fractional distillation
   d. Determining the moisture content, volatile matter, fixed carbon, and ash of a solid fuel
   e. Determination of the flash point of a liquid fuel
   f. Determination of viscosity of oils
   g. How is heat transferred through conduction, convection, and radiation?
   h. Other projects suggested by pupils
3. *Culminating activities*
   a. Committee reports and displays
   b. Other activities suggested by pupils
4. *Textbook and reference study*
5. *Evaluation* (See p. 277.)
6. *Use direct teaching where needed*

Unit XIV

HOW DO WE USE ACIDS, BASES, AND SALTS?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. How can we recognize an acid, a base, or a salt?	1. To learn the characteristics common to typical acids, bases, and salts	1. *By class or committees with reports*
2. What happens when acids and bases come together?	2. To learn to understand and apply the principles of neutralization	a. Students bring in foods and household articles and make tests to determine whether they are acids, bases, or salts
3. How can we safely handle harmful acids and bases?	3. To recognize the need for caution when handling certain acids and bases	b. Students test the shelf acids and bases for action on litmus and other indicators
4. How can I determine whether the soil is sweet, sour, or neutral?	4. To learn how to test for acidity and alkalinity	c. Students test the shelf acids and bases for their behavior toward metals, paints, materials, etc
5. How does the presence or absence of acids, bases, salts, and elements affect plant growth?	5. To gain a better understanding for the control of plant growth	d. Through cooperative planning students may make a list of the common acids, bases, and salts and their uses in everyday activity
6. How can I grow plants without soil?	6. To learn to use intelligently some common acids, bases, and salts	e. Students bring in soils, test the acidity, and change it through the addition of acids, bases, or salts to another pH value
7. How can I control the amount of acid and base in soil?	7. To learn to understand the principle of hydrolysis	f. Students make a study of the pH necessary for the growth of some common vegetables and flowers
8. How can we employ bases, acids, and salts as paint removers, drain cleaners, cesspool cleaners, general household cleaners, etc.?	8. To gain an understanding of ionization	g. Students interview farmers on the importance of the addition and control of fertilizers to soil
9. Is there any danger in the free use of baking soda?	9. To learn to guide oneself in the purchase of household commodities	h. Students experiment with the addition of fertilizers to a section of lawn on the campus
10. How can I use soaps, soap powder, powdered soap, detergents, and scouring powder most wisely?	10. Other objectives suggested by pupils	
11. Do I need a commercial water softener?		

UNIT XIV—Continued

HOW DO WE USE ACIDS, BASES, AND SALTS?—Continued

Content	*Objectives*	*Activities*
		i. Students attempt to grow plants without soil j. Reports from *Consumers' Research* or *Consumer Report* on soaps, soap powders, detergents, etc k. Students interview plumbers, welders, and painters on how they use acids, bases, and salts in their everyday activities l. Demonstration of ionization or dissociation 2. *Experiments* 1. Neutralization and the preparation of a salt 2. Determining the acidity in vinegar through titration 3. Making of soap 4. Hydrolysis 5. Making and softening hard waters 6. Deliquescence and efflorescence of substances 7. Other projects suggested by pupils 3. *Culminating activities* 1. Committee reports and displays 2. Other activities suggested by pupils 4. *Textbook and reference study* 5. *Evaluation* (See p. 277.) 6. *Use direct teaching where needed*

UNIT XV

HOW CAN WE AVOID THE WASTE OF METALS?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. What are the general characteristics of metals?	1. To learn that metals differ from each other in activity and uses because of a difference in properties	1. *By class or committees with reports*
2. Do we need to conserve our supply of iron ore and other metal ores?	2. To gain a better understanding for a more intelligent use of metals	a. Make a collection of various metals and study the similarities and differences in their physical properties
3. How are iron and steel obtained from ore?	3. To appreciate the need for conserving metals	b. Plan a list of properties of metals that you would like to know more about, and make a study of these properties
4. How extensively are iron and steel employed in everyday living?	4. To learn how metals can be protected from corrosion	c. Visit a metal fabricating plant, electroplating plant, a steel plant, or any other processing plant if possible
5. How can rust and corrosion be prevented?	5. To learn how to clean corroded metals	d. Make a survey of the metals that our country lacks and indicate our present source of these metals
6. How can rust be removed?	6. To appreciate the need for dependence on other nations for our requirements	e. Make a survey of the sources of supply of metal ores in the United States and possible duration of these sources
7. How can silverware be cleaned?	7. To learn to appreciate our great dependence upon metals for our daily activities	f. Make a survey to learn how we may conserve our metals
8. How do other metals, such as aluminum and copper, serve us?	8. To show that our available metal supply is exhaustible	g. Refer to your study in history and report on the meaning of "Bronze Age" and "Iron Age"
9. How are metal oxides and other metal compounds employed in making paint?	9. To gain a better understanding of the fundamental physical and chemical principles related to the behavior of metals	h. Study the composition of a number of ores and learn how the metals are obtained from them
10. What are the qualities of a good paint?	10. To learn about jobs in mineral industries	
11. Other problems suggested by pupils	11. Other objectives suggested by pupils	

UNIT XV—Continued

HOW CAN WE AVOID THE WASTE OF METALS?—Continued

Activities

i. Make a collection of rusted objects and study the methods most practical for removing the rust

j. Show films on the manufacture or processing of some metals

k. Have pupils bring in tarnished silverware and learn to clean it electrolytically

l. Make a survey of the more important alloys of the different metals, learning their uses and properties

m. Make a study of the more important compounds of the metals and how we use them

n. Report on a study of paints made by *Consumers' Research* or *Consumer Reports*

o. Make a chart of jobs, pay, etc.

2. *Laboratory experiments*
   a. Displacement of metals
   b. Metallurgy
   c. Tempering of steel
   d. Soldering or welding of metal and use of fluxes
   e. Electroplating
   f. Coefficient of expansion of metals
   g. Making an alloy (Wood's metal)
   h. Making paint
   i. Other projects suggested by the pupils

3. *Culminating activities*
   a. Committee reports and displays
   b. Other activities suggested by pupils

4. *Textbook and reference study*

5. *Evaluation* (See p. 277.)

6. *Use direct teaching where needed*

UNIT XVI

HOW DOES THE BODY RESEMBLE A CHEMICAL PROCESSING PLANT?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. What shall we eat?	1. To develop an understanding of how a body resembles a chemical processing plant	1. *By class or committees with reports* a. Through group organizations make a study of
2. How does our body chemically process what we eat?	2. To develop a sense of food values which will contribute to effective behaviors in eating	(1) The four corner stones of nutrition and relation of basic food groups
3. How does a deficiency in a certain food affect the proper functioning of the body?	3. To acquire a knowledge of the functions of the nutrients for body growth and maintenance	(2) How the body processes the food through the secretions of the salivary glands, pancreas, stomach, liver, etc.
4. What kind of water shall we drink, and how much of it?	4. To develop an understanding of the food cycle	(3) Deficiency of elements in plant and animal development
5. How are we supplied with the needed water?	5. To develop an understanding of the dependence of plants, animals, and humans, one upon the other	(4) Sources of water supply in our area
6. Why does our body require a large supply of fresh air, and how can we obtain it?	6. To gain a better understanding of present-day food fads, fallacies, and superstitions	b. Visit the reservoir that supplies the water and study the method of purification
7. Are preservatives in foods harmful to the body?	7. To develop an ability to find authentic information concerning nutrition in current books and periodicals	c. Visit a productive farm or garden
8. Does soil richness affect the nutritive value of food?	8. To develop a sense of value in drinking water and need for doing so	d. Make a study of the food diets of the individuals in the class
9. How does the indiscriminate use of alkalizers, laxatives, headache remedies, pain-killers, etc., alter the functioning of the body?	9. To acquire a better understanding in the use of alkalizers, headache remedies, laxatives, etc.	e. Draw a plan for good ventilation in the home
10. What drugs, patent medicines, cosmetics, etc., should I buy?		f. Reports on alkalizers, cosmetics, etc., from *Consumers Union*, *Consumers' Research*, and *Consumer Reports*

UNIT XVI—Continued

HOW DOES THE BODY RESEMBLE A CHEMICAL PROCESSING PLANT?—Continued

Content

11. How can I make a wise purchase of food?
12. Why is sanitation significant in preparation of foods?
13. How do food laws protect us?
14. How can food be kept from spoiling?
15. Other problems suggested by pupils.

Objectives

10. To develop the ability to choose a well-balanced diet even during unhealthful economic conditions
11. To develop an ability to be a wise buyer of foods
12. To develop an ability to learn how to preserve food
13. To develop a sense of responsibility in the sanitary handling of foods
14. To become acquainted with laws that protect us from purchasing adulterated foods and drugs
15. To learn about jobs in food processing and selling
16. Other objectives suggested by pupils

Activities

g. Report on the Food, Drugs, and Cosmetic Act of 1938

h. Acquire copies of your state and local food laws

i. Collect and describe some adulterations and misbranding in food and other preparations

j. Collect labels of canned and bottled foods and note the preservative that is used

k. Visit a food processing plant or write for information on processing of foods

l. Prepare posters picturing results of good and poor diets

m. Collect newspaper and magazine articles concerning foods and diets

n. Make a chart of jobs and pay

2. *Laboratory experiments*

   a. Testing for proteins, starches, sugars, artificial minerals, and vitamins

   b. The effect of saliva, pancreatin, and artificial gastric juice on foods

   c. Use of preservatives in food

   d. Use of aluminum sulphate and lime in the purification of water

   e. How can oils be changed to solids?

   f. Tests for bleached and adulterated food

   g. Other projects of pupils

3. *Culminating activities*

   a. Committee reports and displays

   b. Other activities suggested by pupils

4. *Continuous textbook and reference study*

5. *Evaluation* (See p. 277.)

6. *Use direct teaching where needed*

UNIT XVII

WHAT CAN WE DO WITH SYNTHETICS AND PLASTICS?

Overview by teacher and planning with pupils

Content	*Objectives*	*Activities*
1. What do the terms *synthetics* and *plastics* mean to us?	1. To develop an understanding for the terms *synthetics* and *plastics*	1. *By class or committees with reports* a. Preview Directed guide sheet b. Collect nylon, rayon, and synthetic wool, and make a comparison with natural cotton, wool, and silk fiber c. Test some of the properties of natural and synthetic rubber d. Interview people who have employed synthetic and natural rubber in order to help you to arrive at sound decisions regarding both products e. Make an extensive survey of the uses of cellophane f. Show films on paper, glass, or cement mill g. Visit a paper, glass, or cement mill h. Other projects of the pupils
2. Are rayon and nylon good substitutes for cotton, silk, and wool?	2. To learn that synthetics and plastics eventually find their area of use and will not displace other materials entirely	2. *Laboratory exercises* a. Preparation of nitrocellulose b. Preparation of concrete and observation of its setting properties
3. Is synthetic rubber as good as natural rubber?	3. To learn that plastics such as cellophane are good preservatives against corrosion and spoilage	3. *Culminating activities* 1. Committee reports and displays 2. Other activities suggested by pupils
4. How are plastics employed in sanitation and preservation?	4. To gain an understanding of the principles of synthesis and analysis	4. *Textbook and reference study*
5. Why are paper, glass, and cement considered as plastics?	5. To develop an understanding of some of the problems in manufacturing industries	5. *Evaluation* (See p. 277.)
6. How has bakelite taken the place of wood and metals in the construction of many products?	6. Other objectives suggested by pupils	6. *Use direct teaching where needed*
7. How do we use surplus materials for the manufacture of synthetics?		
8. Other problems suggested by pupils		

Unit XVIII

HOW RICH IS PENNSYLVANIA IN MINERAL RESOURCES?

This unit can be organized after the pattern of Unit XXVII in the Chemistry Outline (page 214) provided the activities have not been included in the previous units of the course of study.

Unit XIX

WHAT SHOULD WE KNOW ABOUT CANCER?

Overview by Teacher and Planning with Pupils

INTRODUCTORY

Why is it important for you to know about cancer?

1. Cancer does not often occur in younger people. It usually attacks women over 30, men over 40. But if you learn a few simple facts about the disease you may be able to save the life of someone in your family or of a friend or, some day, even your own life.
2. Every year thousands of people do save their own lives because they know enough about cancer and its warning signals to go to their doctors early—when the disease can still be cured.
3. On the other hand, many thousands who could be cured die of cancer every year because they do not know enough about it. Largely for this reason, cancer is the second greatest cause of death in the United States today.
4. The more all of us know about cancer the more we can control it. History shows us that cancer was a scourge of the human race even in the days of the Egyptians, 3,000 years ago. Through all these years, ignorance, fear, and superstition have kept us from fighting cancer as intelligently as we can now. Today, doctors know more about treating it than they did even ten years ago. But people must go to a physician in time.

What is cancer?

1. Like a house built of bricks, the human body is made up of billions of tiny cells. In the healthy body, these cells grow in a controlled, orderly way. But sometimes they start to grow in a disorderly, uncontrolled way in a particular part of the body. This is called cancer.
2. Sooner or later, cancer cells break away from their original growth and "colonize" in other parts of the body, carried there through lymph canals and blood vessels. This colonization is called *metastasis*. Unless cancer cells are discovered and treated by surgery, X ray or radium before metastasis sets in, it is next to impossible to track them down and destroy them.
3. There are many different forms and types of cancer. All have in common the ability to kill. However, each presents its own peculiar problems in treatment. That is why cancer must always be treated by highly skilled physicians.

What causes cancer?

1. As yet, no one knows. Doctors all over the world are trying to find the cause.
2. Scientists can cause cancer to grow in laboratory animals by using various techniques. Such animals are being studied intensively for a clue to the cause in human beings.
3. Physicians do know what happens in the human body when someone has cancer and what its commonest warning signals are. There are seven of these.

Cancer's seven warning signals

Any one of them *may* mean cancer, but only a doctor can tell.

1. ANY SORE THAT DOES NOT HEAL
2. A LUMP OR THICKENING IN THE BREAST OR ELSEWHERE
3. UNUSUAL BLEEDING OR DISCHARGE

   NOTE: Consult your doctor. Menstrual periods in young girls are often normally irregular.
4. ANY CHANGE IN A WART OR MOLE
5. PERSISTENT INDIGESTION OR DIFFICULTY IN SWALLOWING
6. PERSISTENT HOARSENESS OR COUGH
7. ANY CHANGE IN NORMAL BOWEL HABITS

Cancer is curable when treated early

Although cancer is a disease which is most common among older people, every young person should know that:

1. One of the best ways to guard against cancer or any other disease is to have periodic physical check-ups.
2. Anyone who notices one of cancer's warning signals in himself *should go to his doctor immediately.*
3. Only surgery, X ray, and radium can cure cancer. All home remedies, such as pills, salves, tonics, powders, and all advertised "sure," "special," or "secret" cures are not only useless but dangerous. Using them only keeps people from going to their doctors early enough to be cured.

GENERAL OBJECTIVES

1. To prevent cancer as one of the unsolved health problems of the nation
2. To awaken an interest in the student as to the nature of cancer
3. To develop sound factual knowledge about cancer, its symptoms, possible causes, methods of treatment, and possibility of cure
4. To develop fear-free attitudes about cancer
5. To emphasize the need for frequent complete physical examination to facilitate early detection and diagnosis
6. To stress the importance of consulting a reputable physician, and the avoidance of quackery and patent medicines

7. To suggest health habits which may prevent precancerous conditions
8. To show that cancer is not only a health problem, but a sociological, psychological and economic problem as well
9. To instill in the pupils a desire for further knowledge of cancer
10. To stress the need for making facts about cancer available in order to assist in bringing about the control of cancer

Learning activities (Individual, committee, and class projects with reports on selected activities)

1. Cell growth (in Biology)
2. Normal structure and function of the body (in Physiology or Hygiene)
3. Unnatural growths on plants (in Botany)
4. Morbidity and mortality statistics (in Mathematics)
5. Newspaper and magazine articles describing advances in research on cancer (in Current Events)
6. Radiation (in Physics)
7. Human interest stories of records of cured cancer cases (in Sociology)
8. Let the pupils examine microscopic slides showing normal cells
9. Have pupils compare normal tissue with malignant tissue under the microscope
10. Have the pupils observe several different kinds of both normal and malignant tissue
11. Have the pupils draw their conceptions of a benign tumor and a malignant tumor
12. Let the pupils observe protozoa in the process of cell division
13. Show a film demonstrating normal cell growth
14. Have the pupils collect samples or illustrations of uncontrolled growth on plants so that they may study tumor growths found in plants
15. Have pupils report on a visit to a tumor clinic or a pathology laboratory
16. Show a film on cancer recommended by the local unit of the American Cancer Society
17. Have the pupils report on how frequently they have complete physical examinations and their importance
18. Have the pupils conduct a quiz period testing themselves and each other on knowledge of the "Seven Danger Signals"
19. Have the pupils list advisable hygiene practices to preclude precancerous conditions
20. Have the pupils locate common sites of cancer on a large diagram of the human body
21. Have the pupils color common sites on individual diagrams of portions of the body

22. Have the pupils discuss the value of statistics and their interpretation
23. Have the pupils study statistics about cancer to see if there are any factors which might indicate that the cancer death rate is not increasing as rapidly as supposed
24. Have local physician speak to an assembly about the problem of cancer in the community and State
25. Have the pupils make a chart comparing the incidence of cancer deaths to the deaths from other causes, within the community, county, or State
26. Compare the death rate from cancer in the immediate community, county or State with death rate figures for cancer in other communities, counties or states
27. If possible to secure the facts, have the pupils make graphs or charts showing breakdown of deaths from cancer by sex within the community, county, or State
28. Have the pupils compute the death rate according to ages of individuals, from statistics given above
29. Have the pupils compare the cancer death rate figures of today with those recorded five years ago, to indicate the status of the problem of cancer at the present time
30. Hold a panel discussion or symposium on the question, "Why should everyone know the facts about cancer?"
31. Let the pupils report on cured cancer cases of which they have knowledge
32. Find out by free discussion what misconceptions exist among the pupils with regard to cancer cures
33. Have a class representative report to the class on information about a biopsy as learned from a physician or laboratory
34. Have the pupils write an essay on hopefulness of cancer cure when treatment is early
35. Have a committee report on hospitals and tumor clinics to be found within radius of the community

CULMINATING ACTIVITIES

Pupil reports, panel discussions, exhibits, etc.

EVALUATION

Have the pupils gained the following concepts? (functional unit test or pupil questionnaire)

1. Cancer is not a hopeless disease.
2. Cancer is a disorderly growth of the cells of the body.
3. There is no scientific proof that cancer in humans is contagious.
4. Most types of cancer are curable in the early stages, before spreading to other parts of the body.

5. Early detection, accurate diagnosis, and prompt treatment are essential i the control of cancer.
6. There are seven known danger signals which may mean cancer. Everyon should know them.
7. There are several conditions which are considered to be forerunners t cancer.
8. The three methods of treating and curing cancer are surgery, X ray, an radium.
9. Much progress has already been made in research, and scientists are con stantly at work trying to solve the mystery of cancer.
10. The chief problem today is to make more people thoroughly aware of th facts of cancer, so they will use this knowledge to protect their own healt and that of members of their families.

GROUP DISCUSSION

1. Has the group achieved its objectives in the unit?
2. Have reports and committee activities been of good quality?
3. What need for direct teaching and drill are shown?

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Further assistance and suggestions for the teacher may be had by calling the nearest division of the American Cancer Society.

SOUND FILMS ON CANCER

The sound motion pictures and other materials listed below are available on a "loan basis" FREE to all interested groups as one of the special services of the American Cancer Society county organizations. Please address all requests for films to the County Captain and/or Administrative Officer at the local county ACS Headquarters.

Secondary School Films:

THE TRAITOR WITHIN (16 mm, color) 11 minutes—English language or Spanish language prints available. . . . All mixed audiences: Adult and secondary schools. Not recommended for auditorium programs.

FROM ONE CELL (16 mm, color) 14½ minutes. . . . For high school Biology classes only—not recommended for assembly programs.

CHAPTER IV

EVALUATION IN SCIENCE EDUCATION

THE MEANING OF EVALUATION

The term *evaluation* is more meaningful than the term *measurement*. Evaluation is the process of gathering, interpreting, and using evidence on improvement in the behavior—the thinking, feeling, and acting—of students. It includes as much objective measurement as possible but avoids the narrow pitfalls of interpreting success on the basis of memorized information.

EVALUATION is concerned with the all-round development of the learner. It is a means of appraising all aspects of total growth which indicate how much genuine learning is being achieved.

Research has established that the learner functions as a unit. The various aspects of his personality do not act independently. They are highly correlated. When genuine learning occurs, there is growth in the way in which the learner reacts to his environment and to further learning experiences. This all-round personal growth is well recognized in statements of school and course objectives.[10]

The statement of objectives is but one step in planning a course of study or an experience unit. Learning activities for the attainment of each objective must be organized. In addition, means for the evaluation of each objective must be a continuous and integral part of science education. Otherwise statements of objectives are but sterile phrases.

It is important that evaluation be as comprehensive as possible because it generally determines the type of teaching. The types of appraisal—tests, check lists, questionnaires, and observation—which a teacher uses, set the stage for what is taught and how it is taught. As long as total or major emphasis is placed on the student's ability to recall facts, regardless of their relationships, of their use, or of his needs, teachers will give maximum significance to memorized learning.

Teachers and makers of tests are being challenged to develop comprehensive types of evaluation. Possible negative learnings with respect to some objectives may not otherwise be revealed. Evaluation is one of the most pressing problems of education. Teachers of science, because of their background of measurement and research, are well equipped for creative work in this area.

Dan W. Dodson, managing editor of *The Journal of Educational Sociology,* writes:

> The problem of evaluation is, perhaps, the greatest plague of education today. Of the billions of dollars spent on education

NOTE: The superior figures in Chapter IV refer to the items in the "Suggested Readings" on p. 335.

—one of our greatest American enterprises—we know very little about what action produced what result. No business could afford such an extravagance.

Educators violate almost every tenet they profess when they come up against this problem . . . What we test for as an end result in education is going to determine what we teach.

Has not the time come for American educators to face this problem realistically and develop methods of evaluation which will move the present program out of the doldrums?[4]

Evaluation Based Upon Objectives

The committee which produced *Science Education in American Schools,* the Forty-sixth Yearbook of the National Society for the Study of Education, proposed the following types of objectives: (1) *functional information or facts,* (2) *functional concepts,* (3) *functional understanding or principles,* (4) *instrumental skills,* (5) *problem-solving skills,* (6) *attitudes,* (7) *appreciations,* and (8) *interests.*[10] As these objectives are studied, the broadening of the scope of science education in the last generation is apparent. It is clear also that teaching and evaluation of the desired outcomes—beyond the first objective—have become more important, more varied, and more difficult. Here is a problem on which a science teacher can test his mettle.

S. C. Bolstad, president of the Educational Test Bureau, writes:

The publisher surveys the situation and seems to find that education can be benefited by a new achievement battery of standardized tests, built to meet present-day emphasis in education. What is that emphasis? There is no question about it. The emphasis is on functional education. In building a standardized achievement battery of tests . . . there can be no side-stepping the functional tasks . . . The preliminary tests are sent out and administered . . . However, when these experimental tryouts return to be scored, it is a surprise to find that students score nearly zero on all functional questions. The achievement battery . . . has to be chiefly a test of memorized facts.

The need is to continue to develop functional teaching and not permit ourselves to gallivant off to other thoughts and slogans.[3]

It is apparent that the functional objectives of education are not being fairly met by many present practices and that better evaluation can contribute to better teaching. By the same and other evidence, if the behaviors which are expected from functional teaching are to be evaluated comprehensively, the evaluation must be by methods which are developed, reported, and shared by teachers in action.

The evaluation of these desirable behaviors includes evidence that interests and attitudes are being developed, that work habits and study skills have become more efficient. They reveal themselves in how the student interprets data, thinks both deductively and inductively, attacks problems, and uses facts, concepts, and principles in new situations. They are revealed also in the life adjustments which the learner is making with respect to his imperative adolescent needs—work, health, citizenship, home, thrift, scientific understanding, appreciation, leisure, sociability, and good English usage. At a glance, the obtaining, recording, and reporting of all of these data seem to be work for a paragon of professional proficiency. However, there is much that a busy teacher can do.

Judging the Results of Teaching

The science teacher who would judge the results of his teaching must have a clear idea of why he is teaching. **If the aim is merely to "cover the text," most of the values which science education can provide will be lost. The final test is how well the student meets the problems of learning and of living day by day. Outcomes should be stated and evaluated in terms of the behaviors which are needed to meet those problems. When outcomes are defined in terms of desirable behaviors, instruments for their observation and recording can readily be produced.**

At the same time, there needs to be a departure from the customary role of testing, "to separate the sheep from the goats and to see that the goats don't get a sheepskin." The rapport that characterizes good teaching should also characterize good evaluation. The cooperation of the student in appraising his own growth is an essential procedure in motivation. Working for marks or grades or on a low level of coercion increases the degree of artificial, memorized learning. The tendency of pupils to consider an evaluation a sort of punitive measure is not entirely without foundation. This produces a conflict situation between pupils and teachers. A successful teacher will dissipate this idea. Cooperative means for evaluation have been discussed in the section on "Teaching Science by Units" in Chapter II. This student understanding is one of the behaviors—the thinking, feeling, and acting—which good evaluation will create.

TECHNIQUES OF EVALUATION

Judging the results of functional teaching is similar to a physician's diagnosis. He uses instruments for objective measurements. He secures subjective impressions by consultation. From these, he appraises his

patient's health. The means which are being used in science education for comprehensive evaluation include:

1. **Paper-pencil Forms**

   (a) Improved essay-type examinations, (b) standardized tests, (c) homemade objective tests, (d) behavior rating scales, (e) check lists, (f) pupil logs or diaries on what was learned from day to day or on what contribution the pupil made to a class discussion or project, and (g) questionnaires on pupil needs.

2. **Classroom Questioning and Discussion**

   This type of evaluation should indicate what problems the pupils have. Pupils may be asked to submit problems. Subgrouping may be employed for study, discussions, and reports. A simple check list, used by the teacher, will indicate after each student's name the degree and nature of his participation, perception, and committee leadership.

3. **Laboratory Skills and Behaviors**

   A simple check list of pupils' names and desirable types of behavior is of great assistance in day-by-day evaluation. How a student attacks problems, gets down to work, arranges apparatus, keeps surroundings neat, works with others, uses reference material, weighs evidence, forms conclusions, and reports results are important criteria. Descriptive quantitative ratings or anecdotal recordings of what is actually observed may be used.

4. **Individual Interviews**

   Here there is better opportunity to appraise students' needs, interests, and attitudes than in either a quiz or a discussion. Rapport should be established which will lead the student to talk freely. Brief anecdotal records will be of value to the teachers whose satisfaction comes from helping to produce wholesome men and women as well as scientists. The ability to interview students in this manner can be gained by any teacher. Yet 54 per cent of the 5,000 students questioned in the Inquiry on Student Needs (See Sect. 3, Chapter II) stated that they do not feel free to talk with a teacher on their faculties and 36 per cent of a sampling of dropouts stated that they would have remained in school if any one teacher had been interested in them as individuals.

5. **Questionnaires and Check Lists**

   Tests generally help to determine what a student remembers. One of the best ways to find out how youth thinks, feels, and acts is to ask the students themselves. A questionnaire provides an easily constructed instrument to this end. Pupils express themselves very frankly on questionnaires whether they sign them or not. The reliabilities exceed those of many tests. They can be constructed to measure any aspect of behavior and provide

valid and interesting results both for student self-appraisal and for teacher information. They may be prepared to reveal attitudes, opinions, and behaviors.[12]

Check lists are also easily constructed. They provide for day-by-day student self-appraisal in the development of study habits, health behaviors, and other skills which are needed for living and learning.

EXAMPLES OF THE USE OF MODERN EVALUATION

Examples are always better than advice, yet not so frequent. Good instruments—functional test items, questionnaires, and check lists—are all too scarce. Many more are needed for the later edition of this bulletin. Those that do exist provide valuable suggestions for the construction of more and better ones.

1. *EVALUATION OF A SCHOOL'S SCIENCE PROGRAM*

The inclusion of the following excerpts of Section D-15, Science, of the 1950 *Evaluative Criteria*[5] of the Cooperative Study of Secondary School Standards is by courtesy of the Study. The excerpts provide facts for self-appraisal and curriculum improvement. The teacher is referred to the *Criteria* for complete treatment.

Statement of Guiding Principles

The science curriculum consists of those courses, activities, and units of instruction which are designed to meet pupil educational needs related to science. Major emphasis in the curriculum is upon (1) the understanding and application of major scientific principles; (2) the development of competence in the use of the scientific method; and (3) the development of desirable attitudes, interests, and appreciations related to science and its applications.

The curriculum provides opportunities for all pupils to participate in science activities to meet their common needs and interests. Provision is also made for additional offerings to meet the special needs, usually vocational or technical in nature, of some pupils.

The learning activities are conducted in a classroom-laboratory situation providing opportunity for group instruction and individual and group investigation and experimentation. Pupils also participate in field activities providing opportunity to study and apply scientific principles outside the classroom. Both inductive and deductive techniques are used in the instructional activities to aid pupils in understanding scientific principles and in solving scientific problems. During the learning activities the teacher acts as a guide, keeping a proper balance between pupil-exploration and teacher direction.

Organization

CHECK LIST

( ) 1. General science courses are required of all pupils. (Indicate grades: ____________.)

( ) 2. A unified biological-science course (general biology) is available to all pupils.

( ) 3. A physical-science survey course is available to pupils in grade 11 or 12.

( ) 4. General science courses are allotted a sufficient number of periods per week. (The number of periods per week is ______.)

( ) 5. Advanced science courses are allotted a sufficient number of periods per week. (The number of periods per week is ______.)

( ) 6. Science periods are of sufficient length. (The period length is ______ minutes.)

( ) 7. Provision is made for some pupils to use the science facilities outside regularly allotted class time.

( ) 8. Teachers are allowed time in their assigned duties to prepare for laboratory and demonstration experiments.

( ) 9. Consideration is given to such factors as type of activities, facilities available, and safety of pupils in determining class size.

( ) 10. Others.

Nature of Offerings

CHECK LIST

The science curriculum includes experiences

( ) 1. That develop knowledge, understanding, and appreciation of important principles of science.

( ) 2. That provide practice in applying important scientific principles in laboratory situations.

( ) 3. That develop an understanding of the contributions of science to daily life.

( ) 4. That integrate facts, concepts, and principles from the several science fields.

( ) 5. That require manipulation of scientific equipment and measurement with scientific instruments.

( ) 6. That provide opportunity for pupils to design and construct technical or semitechnical apparatus and equipment.

( ) 7. In reading and interpreting various types of scientific publications.

( ) 8. In performing inductive and deductive laboratory experiments.

( ) 9. That develop an understanding of the elements of the scientific method.

( ) 10. That encourage the development of a variety of scientific interests.

( ) 11. That provide opportunity to study problems involving science in the home and local community.

( ) 12. That develop an understanding of the place of science in the conservation of natural and human resources.

( ) 13. That emphasize recent scientific developments (e.g., atomic energy, rocket propulsion, sulpha drugs).

( ) 14. That aid pupils in developing desirable scientific attitudes.

( ) 15. That include experiences with community resources through field activities.

( ) 16. Others.

Physical Facilities

CHECK LIST

( ) 1. General science and biology rooms are of sufficient size to accommodate largest class without crowding.

( ) 2. Chemistry and physics rooms are of sufficient size to accommodate largest class without crowding.

( ) 3. A work area, set apart from the regular science classrooms, is provided for activities by individuals and small groups.

( ) 4. A fully equipped demonstration area or table is provided which is easily visible to all members of a class.

( ) 5. Science rooms are equipped for use of audio-visual equipment.

( ) 6. Audio-visual projection equipment is available.

( ) 7. Ventilation is provided to free instructional areas of dangerous or unpleasant gases.

( ) 8. Laboratory tables are provided for individual and small-group work.

( ) 9. Acid-resistant sinks are provided.

( ) 10. Cabinets or cases are available for display of materials.

( ) 11. Storage space is provided for laboratory supplies and equipment.

( ) 12. Chemistry materials and equipment are provided for class use.

( ) 13. All chemicals are stored safely.

( ) 14. Biology materials and equipment are provided for class use.

( ) 15. Physics materials and equipment are provided for class use.

( ) 16. Demonstration equipment is readily available.

( ) 17. First-aid kits, neutralizing solutions, and water are readily accessible to the pupils.

( ) 18. Gas and electricity are available for pupil use.

( ) 19. An aquarium is provided in each classroom used for biological science.

( ) 20. A terrarium is provided in each classroom used for biological science.

( ) 21. A system of record-keeping for equipment and supplies is used.

( ) 22. Others.

Direction of Learning

Instructional Staff

CHECK LIST

All members of the science staff

( ) 1. Have had preparation in biological sciences.

( ) 2. Have had preparation in physical sciences.

( ) 3. Have had preparation in social sciences.

( ) 4. Have had intensive preparation in the science area in which they are now teaching.

( ) 5. Have had preparation in methods of teaching science.

( ) 6. Have had preparation in mathematics.

( ) 7. Are acquainted with recent scientific developments and their educational implications.

( ) 8. Are acquainted with recent developments in the *teaching* of science.

( ) 9. Have participated in science activities in industry or business.

( ) 10. Are familiar with community resources.

( ) 11. Are continuing their in-service education.

( ) 12. Assist the librarian in the selection of science reading materials.

( ) 13. Others.

Instructional Activities

CHECK LIST

( ) 1. Instruction in science contributes to the school's objectives.

( ) 2. Instruction is directed toward clearly formulated, comprehensive (or long-range) objectives in science.

( ) 3. Specific instructional activities contribute to the comprehensive objectives of the science program.

( ) 4. There is evidence of careful planning and preparation of the instructional activities.

( ) 5. Flexible or differentiated assignments are used to provide for individual pupils.

( ) 6. Scientific resources of the community and environment are used.

( ) 7. Pupils participate in planning, conducting, and evaluating the instructional activities.

( ) 8. Science activities of varying degrees of difficulty are provided.

( ) 9. Pupils are encouraged to raise and define scientific problems.

( ) 10. Pupils use science activities to collect data and interpret hypotheses.

( ) 11. Particular emphasis is placed on experiments.

( ) 12. A desirable balance between student exploration and teacher guidance is maintained.

( ) 13. The classroom instructional activities are integrated, whenever desirable, with extra-class science activities.

( ) 14. Models, charts, and specimens are used in the instructional activities.

( ) 15. Effective use is made of audio-visual aids in the instructional activities.

( ) 16. Superior students are encouraged to conduct more advanced science projects and experiments.

( ) 17. Field trips are conducted.

( ) 18. Others.

Instructional Materials

CHECK LIST

( ) 1. A variety of textbooks and reference materials is available.

( ) 2. Reading materials are available which provide for differences in the reading abilities and science backgrounds of pupils.

( ) 3. Science pamphlets and non-textbook materials are available.

( ) 4. Science magazines are available.

( ) 5. Well-edited booklists are available.

( ) 6. Teacher-prepared materials (such as study guides) are available.

( ) 7. Films, filmstrips, and slides are available.

( ) 8. Microprojection apparatus is available.

( ) 9. Models and specimens are provided.

( ) 10. Charts, maps, and similar visual aids are provided.

( ) 11. Audio aids are available for classroom use.

( ) 12. Others.

Methods of Evaluation

CHECK LIST

( ) 1. Evaluation is an integral part of the instructional activities.

( ) 2. Evaluation activities place emphasis upon the growth of the individual toward appropriate objectives in science.

( ) 3. A variety of testing techniques is used (e.g., standardized tests, teacher-made objective tests, essay examinations).

( ) 4. Diagrams, charts, and pictures are used in tests and evaluation.

Methods of Evaluation—Continued

CHECK LIST

( ) 5. Objective evaluation is made of the laboratory activities of the pupils.

( ) 6. Evaluation is made of pupil reports of their own laboratory investigations.

( ) 7. Evaluation is made of pupil ability to apply the elements of scientific method.

( ) 8. Evaluation is made of pupil science projects which are conducted out of school.

( ) 9. Pupils participate in the evaluation of their own progress in the learning activities.

( ) 10. Results of evaluation are used in assisting pupils in their selection of advanced science courses.

( ) 11. Evaluation of behavior changes uses results from informal conversation with pupils, classroom discussions, and interviews with parents.

( ) 12. Both teachers and pupils recognize that tests should be used to reveal strengths and to point out areas for improvement.

( ) 13. Others.

Outcomes

EVALUATIONS

( ) a. *To what degree do pupils exhibit an understanding of scientific principles?*

( ) b. *To what degree do pupils possess skill in interpreting science information and literature?*

( ) c. *To what degree do pupils possess skill in using scientific apparatus?*

( ) d. *To what degree do pupils exhibit ability to apply the elements of scientific methods in solving problems?*

( ) e. *To what degree do pupils exhibit an interest in science as shown by their leisure and hobby activities?*

( ) f. *To what degree are pupils acquiring scientific knowledges and skills to prepare them for work or further education?*

( ) g. *To what degree do pupils possess a knowledge of vocational opportunities open to them in the field of science?*

2. *STUDENT EVALUATION OF THE TEACHING*

Student evaluation of the teaching can be of great value. As partial evidence of the results of teaching, it can help to provide direction for curriculum improvement. The learner's reaction determines, to a great extent, the nature and effectiveness of what he learns.

It requires courage for a teacher to seek this evidence by questionnaire. It will be more valid in this case if questionnaires are not signed. When mimeographed, items may be changed to meet local conditions.

Student Questionnaire on Science Teaching

Here is a list of statements about your science course. What do you think is good and what not so good? You are asked to check the statements, under Yes, Doubtful(?), or No—so that there may be a good report on what you think. You need not sign your name.

Check each statement truthfully and thoughtfully so that the best kind of course can be planned for you and for those who will follow you.

Examples

	Check Yes	D.	No
The topics I study in science are very valuable to me.	√		
My fellow students are friendly.		√	
My teacher is hard to get to know.			√

Your Opinions

	Yes	D.	No
1. This science course is very interesting to me.			
2. I am getting information that will be valuable all my life.			
3. This course will help me in my chosen occupation.			
4. The way this class is run helps me to make friends.			
5. Sometimes the subject is "over my head."			
6. I would be learning more if I were working somewhere.			
7. I have trouble in studying science.			
8. The teacher seems to have some favorites in this class.			
9. My assignments in this class are clear and definite.			
10. My work in science is teaching me to think scientifically—to consider facts and make decisions.			
11. Most of my work in this course is done so that I can get a good grade.			
12. My teacher is up to date in what he knows and does.			
13. The teacher in this class does most of the talking.			
14. I am learning how to do experiments and handle apparatus.			
15. I would like to have a science laboratory of my own.			
16. My teacher should mix more freely with the students.			
17. I am afraid when I am called on to make reports.			
18. I have opportunities to act as a leader in this class.			
19. My teacher praises pupils more often than he blames them.			
20. The pupils in this class help to plan the work.			
21. I feel free to talk over my personal problems with my teacher.			
22. My teacher seems to like his job.			
23. My teacher has a good sense of humor.			
24. Disciplinary cases are well handled in this class.			
25. I am enthusiastic about my work in this class.			

If you were planning for this class, what changes would you make? List any changes. Use the other side of this paper.

3. *EVALUATING STUDENT ACHIEVEMENT*

The following self-appraisal student rating chart may be used once each semester in a class or homeroom: (1) to stimulate needed self-analysis, (2) to call attention of students to areas of personal growth, (3) to recognize these areas as goals, and (4) to evaluate progress. The items may be changed to suit local conditions when the chart is mimeographed.

Student Questionnaire—What Are You Learning?

What kind of person a youth becomes is as important as what be learns. Education is concerned with each student's growth as an individual. This chart is intended to help you to see where you are and how you can improve.

You should rate yourself. Then the teacher will add his rating, after which a conference may be held. If you do not know the meaning of any words, look them up.

____________________ NAME   ____________________ HOMEROOM   ____________________ CLASS SECTION

Mark an X in the square which best describes how you usually think, feel, or act with respect to the need which is in the first column.

Needs	(1) *Doubtful*	(2) *Passive*	(3) *Productive*	(4) *Constructive*	(5) *Creative*
Work	Gives up Careless Shuns work	Dependent Submissive Follows others	Interested Loyal Leads sometimes	Definite Strong Often leads	Diligent Confident Makes things go
Health	Slovenly Depressed Stolid	Neat Willing Promising	Healthy Alert Active	Brisk Cheerful Vigorous	Exuberant Enthusiastic Vitalizing
Citizenship (At School)	Unsound Annoying Critical	Indifferent Unconcerned Conforms	Interested Loyal Careful	Devoted Eager Dependable	Stimulating Inspiring Influential
Homeroom (Attitude)	Petty Anxious Impatient	Rough and Ready Thoughtless Easy-going	Cheerful Deliberate Cooperative	Polite Tactful Warm-hearted	Successful Poised Gracious

THRIFT	Frivolous Buys on whim Wastes time	Muddled Gullible Impulsive	Serious Knows values Purposeful	Sound Keen bargainer Determined	Reliable Brilliant trader Independent
SCIENCE	Opinionated Irrational Prejudiced	Credulous Confused Snap judgment	Open-minded Seeks proof Sticks to facts	Curious Systematic Weighs evidence	Inductive Rational Keen
APPRECIATION	Vulgar Common Critical of best	Superficial Erroneous Coarse	Knows form Has good taste Recognizes merit	Enjoys form Refreshing Refined	Artistic Creative Elegant
LEISURE	Cheap taste Childish fun Rough	Underbred Follows others Negligent	Restrained Normal pursuits Respects the best	Good hobbies Has some sport Many-sided	Ingenious Mature tastes Enjoys art, music
SOCIABILITY	Self-centered Timid Rude	Indifferent Passive Proper	Accepted Cheerful Sympathetic	Sought after Active Helpful	Esteemed Magnetic Influential
LANGUAGE	Careless Peculiar Dormant	Unreliable Deficient Developing	Accurate Practical Passable	Skillful Forceful Desirable	Colorful Persuasive Delightful

Credit yourself 1, 2, 3, 4, or 5 from left to right for the x's in the five columns.

What is your score? *How can you rate higher?*

Test Items That Measure Ability in Scientific Thinking

In addition to the customary test items which measure the memory of factual data, there is need for many items which measure student ability: (1) to interpret data, (2) to weigh evidence, (3) to form generalizations or principles, (4) to apply generalizations or principles to new situations. Every science test should contain paper-pencil items. The following examples will suggest to the teacher many similar items which can be included in homemade tests. Your State Science Committee needs many items of these types.

1. Ability to Interpret Data

Test Item

Substance	*Solubility at 20° C.*	*Solubility at Boiling Point of Saturated Solution*	*Boiling Point of Saturated Solution in Degrees C.*
NH_4Cl	37.2	88.9	114.2
$BaCl_2$	35.7	60.1	104.4
$CaCl_2$	74.5	325.0	179.5
$Ca(OH)_2$	0.165	0.05	100.0
$FeSO_4$	26.5	177.8	102.2
K_2CO_3	110.5	205.0	135.0
KNO_3	31.6	284.6	114.5
K_2SO_4	11.11	21.21	101.7
NaCl	36.0	41.2	108.4
Na_2SO_4	15.0	43.0	103.0

Check the appropriate space on the right which indicates that:

	1	2	3
1. The conclusion is clearly indicated by the above data.	√		
2. The conclusion may be true but is not indicated by the above data.		√	
3. The conclusion is unsupported by the above data.			√

CONCLUSIONS

	1	2	3
1. The greater the weight of the solute present, the higher the boiling point of the saturated solution.			
2. All substances increase in solubility as the temperature is increased.			
3. Potassium salts undergo the greatest increase in solubility as the temperature is raised.			
4. Sulfates have the lowest boiling points found among saturated salt solutions.			
5. Chlorides have the highest boiling points found among saturated salt solutions.			
6. The boiling points of saturated salt solutions do not depend upon the rates at which their solutes increase in solubility with increase in temperature.			

2. Ability to Apply Generalizations to New Situations

a. Test items of this type measure the most vital outcomes of functional science education. The real test of education is the ability to apply it to daily living as an explanation of phenomena, and to further science education.

Items for the evaluation of these abilities can readily be developed from the Daily Phenomena and Scientific Principles which are included in the Student Self-Appraisal Check Lists to be found in Chapter III, Scope and Sequence.

Either of the two columns can be made the base for a requirement for filling in the other column. For example:

TEST ITEM

List eight scientific principles or laws in brief which are illustrated by any of the following industrial uses or machines:

Uses or machines	*Scientific Principles*
	(Student's answers)
air compressors, air brakes, drying clothes, engines and motors, pumps, vacuum cleaners, tires, sprayers, carburetors, siphons, milking machines, ventilation	1. Molecular action 2. Gas pressure 3. Temperature change 4. Vaporization 5. Atmospheric pressure 6. Weight of gas 7. Charles' laws 8. Gay Lussac's law

Conversely, an item may be framed to read as follows: Name ten uses or machines which employ the scientific principles which are listed.

b. Another type of test item designed to measure or show ability to apply principles or knowledge is as follows:

TEST ITEM

According to the kinetic-molecular theory:

(1) All matter is made up of molecules.
(2) These molecules are in continuous motion.
(3) Molecules have an attraction for one another.
(4) If any material is heated, its molecules move with increased speed thus causing them to spread farther apart.

The molecular theory explains the following phenomena:

(a) Capillary action, (b) Cohesion, (c) Adhesion, (d) Expansion, (e) Elasticity, (f) Diffusion, (g) Surface tension.

After each statement put first the letter indicating the name of the above phenomenon, and second the number of the statement which causes the phenomenon.

	Letters	*Numbers*
1. A bottle of ammonia opened in one corner of a room may soon have its odor detected in any part of the room.	1.________	________
2. Water rises in the soil.	2.________	________
3. A steel razor blade can be made to float on water.	3.________	________

4. Wiping your hands on a towel will dry them. 4.________ ________

5. A small amount of sugar dissolved in water makes all the water taste sweet. 5.________ ________

6. Gases increase in volume when heated. 6.________ ________

7. Lime sticks to the hands. 7.________ ________

8. If you put your finger in mercury it does not become wet. 8.________ ________

9. Mucilage will cause two pieces of paper to stick together. 9.________ ________

10. The crack between two adjoining railroad rails widens in winter. 10.________ ________

3. Test Items Involving Students' Ability to Do Discriminative Thinking and to Synthesize Their Knowledge

Suppose a physics teacher has taught the units on sound and light, but he has not stressed the similarities or differences. Then the following would require discriminative thinking.

Write in the space below the letter indicating the correct statement for each numbered item.

A The item is true of light only

B The item is true of sound only

C The item is true of both sound and light

D The item is true of neither sound nor light

1.______Its velocity in air is greater than in water

2.______It can travel through a vacuum

3.______It can be reflected

4.______It requires energy for production

5.______It can be refracted

4. Test Items Effective in Measuring How Students Can Make Comparisons Based on Discriminative Thinking and Synthesis of Knowledge:

Write in the space below the letter indicating the correct statement for each numbered item.

A The item on the left is greater than the item on the right

B The item on the right is greater than the item on the left

C The two items are essentially the same

1.______Density of metals ...Density of nonmetals

2.______Thermal conductivity of metals ...Thermal conductivity of nonmetals

3.______Oxidizing power of chlorine ...Oxidizing power of bromine

4.______Reducing ability of sodium ...Reducing ability of cesium

5.______Acidity of oxides of metals ...Acidity of oxides of nonmetals

5. Test Items to Measure How Students Can Handle Correlated or Cause and Effect Relationships*

On the line preceding each of the following paired items, write the letter which applies

A If increase in one of the situations referred to is usually accompanied by *increase* in the other

B If increase in one of the situations referred to is usually accompanied by *decrease* in the other

C If one of the situations referred to tends to remain the *same* when the other increases or decreases

D If the two are totally unrelated

1.______Amount of carbonates dissolved in the water of a river
Number of clams in the river

2.______Temperature of the environment of a bird or mammal
Body temperature of the bird or mammal

3.______Size of the orbit of a planet
Period of revolution of the planet

4.______The mass of a body or object
The speed at which the body falls in a vacuum

6. True and False Testing (Check *T* or *F*)

a. *Testing to Appraise Cause and Effect Relationships*

T F Boards will always warp if they are piled out of doors in the light of the moon.

T F A falling barometer indicates rain.

T F Throwing salt over the shoulder will drive away bad luck.

T F The rate of plant growth depends upon the sun, rain, and soil.

T F Handling toads causes warts to grow on the hands.

b. *Testing to Appraise Honesty*

T F When a pupil has a chance to get help while taking a written test, it is all right to do so if the teacher is not looking.

T F It is better to fail than to cheat.

T F It is justifiable to walk into a football game without a ticket if the ticket-taker is not watching.

T F The satisfaction of being honest is better than any other reward.

T F It is justifiable to keep a purse containing a considerable sum of money and say nothing about it if you found it and no one saw you find it.

T F Experiments should be reported with observations uninfluenced by preconceived ideas.

T F It is justifiable to refrain from paying a debt if your creditor does not send you a bill.

T F When a fellow student wants aid on a test, it is best to help to teach him to be responsible for himself.

Many other approaches can be worked out to measure skill, attitudes, and application of knowledge.

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* *Measurement and Evaluation in the Secondary School,* Greene, Jorgensen, Gerberich (Longmans, 1948 ed., pages 422-426) gives examples of various types of questions and means of testing scientific attitudes, application of principles, ability to distinguish between fact and theory, etc. There are examples to measure intellectual honesty, open-mindedness, cause and effect relationships, suspended judgment, criticism, and the like.

7. ABILITY TO WEIGH EVIDENCE (Page 333)

Leads to	*Irrelevant*	*Leads away*	*Statements*	*Fact*	*Assumption*	*Undecided*
			1. The paper had forecast an eclipse of the sun for this month.			
			2. The moon was full on this day.			
			3. This was the day of May 14, 1929.			
			4. No eclipse of the moon can occur when there is a full moon.			
			5. It was evening, and the sun was setting.			
			6. A cloud had appeared and partially covered the sun.			
			7. It had been a clear day with no clouds in the sky.			
			8. The boys were in an open field.			
			9. As one of the boys looked up, he saw a disc creeping across the face of the sun.			
			10. The boys were playing close to a tall building.			
			11. Both noticed that the light was growing dim.			
			12. The science teacher had told them to expect an eclipse that day.			
			13. The boys' science teacher was a reliable instructor.			

c. *Testing or Supporting Evidence*

In the space provided place the letter:

A If the statement is true and the reason given supports the statement.

B If the statement is true and the reason given does not support the statement.

C If the statement is false.

1.______A vibrating tuning fork cannot be heard in a vacuum, because only air transmits sound waves.

2.______Middle C of the violin sounds different from middle C of the piano, because of difference in frequency.

3.______The speed of sound waves in warm air is greater than in cold, because the speed depends in part on the density of the air.

4.______Sound waves are transmitted only by gases, because only gases transmit longitudinal waves.

7. Ability to Weigh Evidence—The Nature of Proof

TEST ITEM

Two boys from a science class had been discussing how the sun and moon might be eclipsed when they noticed suddenly that the light was growing dim. Whereupon one exclaimed, "We must be having an eclipse of the sun!" Was his inference sound?

Directions for Part I.

Statements are sometimes made which actually lead away from the conclusion, or which, though true, have nothing to do with it. Read carefully each statement on p. 332. Accept each statement as true. Then, decide: Does it lead to the conclusion? Or, does it lead away from the conclusion? Or, does it have nothing to do with the conclusion—that is, is it irrelevant? Next, check each statement in the appropriate column at the left. (Disregard at this time the columns to the right.)

Directions for Part II.

Another way to test a proof is to identify the part of the evidence which can be accepted as fact and to determine what part of the evidence must be regarded as assumption.

This time do not accept the thirteen statements on page 332 as true. Instead, critically examine each one in the light of the conclusion and mark in the appropriate column at the right whether it is a fact or an assumption or whether you are undecided what to call it.

8. Novelty Questions which Establish Good Rapport

a. Let us assume you could live on the moon. Certain signs are located in various areas bearing the following statements or warnings

Write the letter *A*, if the sign would be useful; *B*, if the sign would not be necessary.

1.______No swimming allowed!

2.______Keep off the grass!

3.______The plane leaves in ten minutes.

4.______Jumping over this building prohibited.

5.______Please do not shout.

6.______Look out for meteors!

7.______See the lovely sunset from this point of vantage.

8.______No smoking!

b. Suppose that Dalton, Madame Curie, Aristotle, Democritus, and Becquerel are broadcasting a roundtable discussion from Radio Station S T Y X. Identify the speaker of each *numbered* statement by using the following code:

A Madame Curie
B Democritus
C Becquerel
D Aristotle
E Dalton

One of the group begins the discussion by saying, "A few days ago I read the following paragraph in a recently published chemistry textbook:

" 'Can all forms of matter—all substances—be divided continuously and without limits into smaller and smaller particles, each particle always retaining properties that identify it as a portion of the substance that is divided? Or is it possible finally to obtain by division ultimate particles—particles that cannot be further divided without destroying the properties and the identity of the substance?'

"Now what are the viewpoints of the round table concerning this problem?"

______1. "Well, since I was given credit for the first atomic or particle theory of matter, my atoms were considered to be the ultimate particles of all matter; there are as many kinds of atoms as there are varieties of matter."

______2. "The explanation is quite simple, because I experimentally proved and demonstrated the Law of Multiple Proportions. This convinced me that matter is made up of ultimate particles called atoms; and they can't be divided into anything else."

______3. "But you seem to forget, my friends, that these atoms and elements of which you speak are not all stable, permanent, and ultimate particles. I personally discovered that some disintegrate and decompose, spontaneously liberating energy and smaller particles. Remember? I got the Nobel Prize for this."

______4. "This discussion is too much for me! There are no such things as atoms and elements. Didn't I discard the elemental and atomic concepts, and conclude from my observations that all matter consists of a fundamental substance called hyle? And too, the properties or qualities possessed by all forms of matter are only wetness, dryness, cold, and heat."

______5. "I do not agree with the last remark! My contention is that my distinguished colleague, the Nobel Prize winner, is correct. I substantiated his findings, and further investigated the phenomenon of spontaneous disintegration of matter. This work laid the foundations for further research which definitely proved that atoms are not the ultimate particles, but that there are still smaller particles and units which make up atoms."

"I am sorry, but we must bring this program to a close. I wish to thank each one of you for coming here today. Our listeners will no doubt agree that the age-old problem of the composition of matter is now much clearer."

[Sign-off.]

SUMMARY

1. Evaluation is the process of gathering, interpreting and using evidence on the growth in the way students think, feel, and act. It includes measurements and other dimensions as well.
2. The learner functions as a unit. As growth is comprehensive, so must be its evaluation. Otherwise teaching and learning may result only in the artificial memorization of factual information.
3. What is evaluated determines what is taught.
4. Few tests can be purchased to measure functional outcomes. These must be teacher-constructed.
5. As much objective measurement as possible must be used. However, to appraise the greater outcomes—understanding, attitudes, and changes in the way students think, feel, and act—questionnaires and check lists are indispensable.
6. Newer type of pencil-paper test items involve the ability: (1) to interpret data, (2) to weigh evidence, (3) to form generalizations or principles, and (4) to apply principles to new situations.
7. Since evaluation is an integral part of teaching, growth toward its objectives should be a constant challenge.

SUGGESTED READINGS

1. Aiken, Wilford M., *The Story of the Eight Year Study.* New York, Harper and Brothers, 1942.
2. Bell, Hugh M., *The School Inventory.* Stanford University, California, Stanford University Press, 1935.
3. Bolstad, S. C., "Develop Functional Teaching," *The Phi Delta Kappan,* Volume XXXI, No. 8, April, 1950.
4. Dodson, Dan W., "Evaluation in Teacher Training," *The Journal of Educational Sociology,* Volume 28, No. 8, April, 1950.
5. *Evaluative Criteria.* Washington, D. C., Cooperative Study of Secondary School Standards, 1950.
6. Haggerty, M. E., Olson, W. C., and Wickman, E. K., *Behavior Rating Schedules.* Yonkers-on-Hudson, New York, World Book Company, 1930.
7. *Learning and Instruction,* Forty-ninth Yearbook, Part I of the National Society for the Study of Education. Chicago, University of Chicago Press, 1950.
8. Leonard, J. Paul, and Eurich, Alvin C., *Evaluation of Modern Education.* New York, Appleton-Century-Crofts, Inc., 1942.
9. Quillen, I. James, and Hanna, Lavone A., *Education for Social Competence.* New York, Scott, Foresman and Co., 1948.
10. *Science Education in American Schools,* Forty-sixth Yearbook, Part I, of the National Society for the Study of Education. Chicago, University of Chicago Press, 1947.
11. Smith, Eugene R., and Tyler, Ralph W., *Appraising and Recording Student Progress.* New York, Harper and Brothers, 1942.
12. Symonds, Percival M., *Diagnosing Personality and Conduct.* New York, Appleton-Century-Crofts, Inc., 1931.
13. Wrightstone, J. Wayne, *Appraisal of Experimental High School Practices.* New York, Bureau of Publications, Teachers College, Columbia University, 1936.

CHAPTER V

REFERENCES AND RESOURCES

BIBLIOGRAPHY AND AUDIO-VISUAL AIDS

Annotated Bibliography on Science Education

Allen, C. R., Lyman, L. B., *The Wonder Book of the Air.* Philadelphia, J. C. Winston Company, 1942.

An interesting book for high school students, especially interested in travel by air.

Almstead, F. E., *Laboratory Manual in Radio.* New York, McGraw-Hill Book Company, Inc., 1943.

This manual contains experimental study of radio and the principles involved.

American Technical Society, *Applied Electricity.* New York, McGraw-Hill Book Company, Inc., 1946.

A complete course in electricity, excellent for use as reference for physics.
American Technical Society, *Science and Life in the World. The Future of Atomic Energy. The George Westinghouse Centennial Forum.* The social and scientific aspects of atomic energy.

American Technical Society, *Applied Electricity, Vol. II.* Chicago, American Technical Society, 1939.

The treatment of electrical theories is clearly brought out without the use of difficult mathematics and unnecessary technical phrases. This book is not too difficult for use by high school physics classes.

American Technical Society, *Applied Electricity, Vol. III.* Chicago, American Technical Society, 1942.

The principle of D. C. electrical machinery with special emphasis on armature winding. Prepared primarily for students preparing for careers in electricity.

American Technical Society, *Fundamentals of Electricity.* Chicago, American Technical Society, 1943.

A good book for physics students doing electrical projects.

Atherton, Ralph, *Principles of Radio for Operators.* New York, The Macmillan Company, 1945.

This book contains material that was used to train men and women as radio operators during World War II. The first part of the book deals with electricity; the remainder pertains to radio. High school science classes would not find this book too difficult, if they had the necessary equipment to work with.

Beauchamp, W. L., *Science Problems.* New York, Scott, Foresman and Company, 1938.
General Science set up in eleven complete units.

Benson, A. L., *The Story of Geology.* New York, Farrar & Rinehart, Inc., 1927.

This book is not too difficult for high school students and it could be used as a reference book for general science.

Betz, William, *Algebra for Today.* New York, Ginn and Company, 1941.

Black, N. H., and Davis, H. N., *Elementary Practical Physics.* New York, The Macmillan Company, 1938.

This book makes an effort to explain clearly as it goes along from simple to complex.

Black, N. H., and Davis, H. N., *New Practical Physics.* New York, The Macmillan Company, 1946.

This book treats physics in the light of its social and industrial uses and handles it as a practical science.

Blackburn, E. F., *Navigation Principles.* Washington, Airlines War Training Institute, 1944.

A book prepared for aircraft flight crews. Too complex for most high school students.

Blair, T. A., *Weather Elements.* New York, Prentice-Hall, Inc., 1937.

This book is an introduction to the science of meteorology. Although meteorology is rarely taught in high schools, this book will make an excellent reference for any science course. Can be used for reference in physics, relative to barometer, and air currents, etc.

Bower, E. O., and Robinson, E. P., *Dynamic Physics.* Chicago, Rand McNally & Company, 1943.

This book is divided into twelve districts or units, and is subdivided into several areas per unit. It has excellent problems and investigations.

Bradley, A. D., *Mathematics of Air and Marine Navigation.* New York, American Book Company, 1942.

This text is suitable for anyone interested in navigation. The student should have had high school trigonometry. Many practical problems to be solved. Probably rarely used in high schools.

Brown, H. E., and Schwachtgen, E. C., *Physics, the Story of Energy.* Boston, D. C. Heath & Company, 1949.

The book is designed for a year's study in high school physics for beginning students. A very readable book.

Brueckner, L. J., and Grossnickle, F. E., *Mathematics We Use.* Philadelphia, The John C. Winston Company, 1945.

This book is for use in the eighth grade. An approach to the practical side of mathematics.

Bureau of Aeronautics, *Principles of Flying.* New York, McGraw-Hill Co., Inc., 1943.

This book explains the whys and problems of flying, and would be a great help both to teachers and students of preflight courses.

Burnett, C., *Atomic Energy.* New York, Charles E. Merrill Company, 1949.

This booklet contains text units on atomic energy for social studies and science. It contains very easily understood explanations on atomic energy and its implications.

Burns, E. E., and others, *Physics, a Basic Science.* New York, D. Van Nostrand Company, Inc., 1943.

This book is good for use in high school physics.

Bush, G. L., *Guided Activities in Senior Science.* New York, American Book Company, 1937.

This manual contains many self-testing exercises, laboratory experiments, and other activities for high school senior science classes. The manual is not difficult.

Caldwell, O. W., and Curtis, F. D., *Everyday Science.* Boston, Ginn and Company, 1943.

Covers the general science field well, contains useful self-tests.

Carlson, Fred A., *Geography of Latin America.* New York, Prentice-Hall Company, 1943.

This book is on a college level, but it could be of a value to high school seniors when studying a unit on foods or textiles.

Civil Aeronautics Administration, *Demonstration and Laboratory Experience in the Science of Aeronautics.* New York, McGraw-Hill Book Company, Inc., 1945.

A good book for high school seniors studying preflight.

Colby, C. C., and Foster, A., *Economic Geography.* New York, Ginn and Company, 1940.

A helpful reference book for science classes.

Conn, H. W., *Bacteria, Yeasts and Molds in the Home.* New York, Ginn and Company, 1932.

A good text for senior high school students in bacteriology. Useful as reference book for other sciences.

Cushing, Burton L., *Fundamentals of Machines.* New York, Ginn and Company, 1943.

Suitable for a physics reference book, when studying the unit on machines.

Davis, D. H., *The Earth and Man.* New York, The Macmillan Company, 1943.

This book is designed for beginning geography classes in colleges and universities. It might be of some use as a reference book to senior science classes in high school.

Earhart, Amelia, *Last Flight.* New York, Harcourt, Brace & Company, Inc., 1937.

Amelia Earhart was lost in the Pacific in July of 1937. Her narrative, *Last Flight,* was edited by her husband, George Palmer Putnam. It is based on cable and telephone messages and notes, and the logbook returned from stopping places en route.

Eby, G. S., and others, *The Physical Sciences.* New York, Ginn and Company, 1943.

Very complete explanations of all aspects of physical science. Useful as reference in physics and chemistry.

Einstein, A., and Infield, L., *The Evolution of Physics.* New York, Simon & Schuster, 1938.

This book is a history and development of physics from early concepts to relativity and quanta. Interesting reading for advanced science students.

Finch, V. C., and others, *Elementary Meteorology.* New York, McGraw-Hill Book Company, Inc., 1942.

This book could be used in the senior year of college. Especially good for preflight courses.

Floherty, J. J., *Behind the Microphone.* New York, The J. B. Lippincott Co., 1944.

An interesting, well-written story about radio broadcasting. Especially valuable to anyone wishing to enter radio as a career.

Fox, Sidney A., *Your Eyes.* New York, D. Daniel Ryerson, Inc., 1944.

What everyone needs to know about his seeing apparatus, for his own good. A well-written informative book.

Fitzgerald, J. A., and others, *Drive and Live.* New York, Johnson Publishing Company, 1937.

High school education in driving.

Fitzpatrick, F. L., and Stiles, K. A., *The Biology of Flight.* New York, The Macmillan Company, 1942.

This book covers the origin of flight, the different insects and birds and the effect of flight upon man.

Fuller, R. W., and others, *Elements of Physics.* New York, Allyn & Bacon, 1948.

This book is suitable for high school physics.

Fuller, R. W., and others, *First Principles of Physics.* New York, Allyn & Bacon, 1932.

This book includes excellent chapter summaries and questions.

Furnas, C. C., *The Next Hundred Years.* New York, Reynal & Hitchcock, 1936.

A very readable book for students interested in science. A good reference book for the several branches of science.

Graham, F. D., *Audels Handy Book of Practical Electricity.* New York, T. Audel & Co., 1929.

This book was primarily designed for professional electricians, but it would be valuable for students in electricity or physics students doing electrical projects. The book contains many wiring diagrams.

Graham, F. D., *Audels Mathematics and Calculations for Mechanics.* New York, T. Audel and Company, 1937.

Excellent reference for mathematics and science students.

Hausmann, E., *Elements of Electricity.* New York, D. Van Nostrand Company, Inc., 1943.

This book presents a basic course in electricity. Since electricity is basic to the study of many other fields in science, this book is very valuable. Many diagrams and illustrations are included.

Hecht, Selig, *Explaining the Atom.* New York, Viking Press, 1947.

This book is designed to help the layman understand the basis and development of atomic energy. It is not difficult reading for the above average and average high school student.

Heitner, Joseph, and others, *Elements of Automotive Mechanics.* New York, D. Van Nostrand Company, Inc., 1943.

An excellent book on elementary automotive mechanics.

Hellman, C. I., *Elements of Radio.* New York, D. Van Nostrand Company, Inc., 1943.

A complete book on the workings of radio. The elements of television are also discussed. Excellent reference for physics students.

Helmholtz, H. L., *Popular Science Talks.* Philadelphia, Philadelphia College of Pharmacy and Science, 1924.

Interesting reading for a better than average high school student who is interested in science.

Henderson, W. D., *Physics Guide and Laboratory Exercises.* New York, Lyons & Carnahan, 1945.

An excellent laboratory guide in physics, can be used with any text. It contains 129 problems and 64 experiments.

Hobbs, G. M., and others, *Fundamentals of Machine.* Chicago, American Technical Society, 1943.

This book was written primarily for those preparing for war service. It could be used as reference book for all physical sciences.

Hobbs, G. M., *Fundamentals of Machine Workbook.* Chicago, American Technical Society, 1943.

This is a workbook to be used with *Fundamentals of Machine* for those preparing for war service. Very well correlated with text, could be used in other courses.

Hobbs, W. H., and others, *Practical Mathematics.* Chicago, American School of Correspondence, 1913.

This book is intended for students of engineering. It has practical problems the engineer meets.

Hobby, O. C., *Mr. Chairman.* New Wilmington, The Economy Company, 1937.

A complete book on parliamentary procedure. Helpful to all clubs and organizations from first year high school through college.

Holdane, J. B., *Science and Human Life.* New York, Harper and Brothers, 1933.

This book is a broad view of science and the social implications to human life. Excellent book for the academically-minded science student.

Hopkins, B. S., and others, *Chemistry and You.* New York, Lyons & Carnahan, 1944.

A practical book in high school chemistry.

Hornung, J. L., *Radar Primer.* New York, McGraw-Hill Book Company, Inc., 1948.

The author treats a highly technical topic in a manner readily understandable by laymen. Useful as reference for high school physics.

Jones, B., *Elements of Practical Aerodynamics.* New York, J. Wiley & Sons, Inc., 1939-42.

A book for advanced students in aviation. Possibly useful for advanced students in preflight as a reference.

Jones, Mack M., *Introductory Shopwork.* New York, McGraw-Hill Book Company, Inc., 1943.

A very handy book for high school students taking a course in industrial arts.

Jordanoff, A., *Through the Overcast.* New York, Funk & Wagnalls Company, 1938.

An interestingly written book for those students interested in flying. Useful as reference book for preflight students.

Jordanoff, A., *Your Wings.* New York. Funk & Wagnalls Company, 1942.

This book is very readable, easy to understand and contains many simple illustrations. An excellent reference book for courses in preflight.

Kuns, R. F., *Automotive Essentials.* Milwaukee, The Bruce Publishing Company, 1941.

This book contains everything about the electrical system of an automobile. It is rather technical in some respects and is intended for automotive mechanics.

Kuns, R. F., *Automotive Service, Vol. I., Unit 3.* New York, The Bruce Publishing Company, 1938.

This booklet deals with transmissions, clutches, universals, and front-wheel drive—a good reference book for a mechanic or for a high school student studying a unit on mechanics in physics, industrial arts, etc.

Kuns, R. F., *Automotive Service, Vol. I., Unit 4.* New York, The Bruce Publishing Company, 1938.

This booklet deals with rear systems and brakes. A good reference book for a mechanic or for a high school student studying a unit on mechanics in physics, industrial arts, etc.

Lawson, T. W., *Thirty Seconds Over Tokyo.* Garden City, Blue Ribbon Books, Inc., 1943.

An exciting eye-witness report of the first bombing of Tokyo. A good story for adventurous high school students.

Luhr, O., *Physics Tells Why.* Lancaster, Jaques Cattell Press, 1943.

This book is interestingly written. It explains in a simple fashion many of the phenomena puzzling to the man in the street and housewife in the kitchen. It also has much value to high school instructors and students.

Lynde, C. J., *Science, Experience with Inexpensive Equipment.* Scranton, International Textbook Company, 1939.

This book is a good aid to science teachers.

Lyon, T. C., *Practical Air Navigation.* Washington, U. S. Government Printing Office, 1940.

This book is designed for use as a text on air navigation in the controlled ground course of the Civilian Pilot Training Program. It is beyond the high school level.

McCarthy, C. A., *A Matter of Time.* New York, Harper and Brothers, 1947.

This book is a history of the ways and means of telling time. It gives the story of the watch, how it is made and what makes it work.

McDougal, W. L., *Direct Current.* Chicago, American School of Correspondence, 1947.

This book is good for advanced students especially interested in electricity. It is good as a reference book for physics students.

McDougal, W. L., *Fundamentals of Electricity for Those Preparing for War Service.* Chicago, American Technical Society, 1943.

A good complete text on electricity. Excellent for high school study of electricity. Excellent for glossary of electrical terms.

McPherson, W., and others, *Laboratory Units in Chemistry.* Boston, Ginn and Company, 1942.

This is a laboratory manual to be used with the author's book *Chemistry at Work.*

Mallory, V. S., *Mathematics for Everyday Affairs.* Chicago, Benjamin H. Sanborn & Co., 1940.

This book is made up of problems we meet in everyday life.

Miller, D. D., *Popular Mathematics.* New York, Coward-McCann, Inc., 1942.

This book is written primarily to interest students in the wide field of mathematics. It might profitably be used in senior high schools by academically minded students.

Millikan, R. A., *Elements of Electricity.* Chicago, American School of Correspondence, 1907.

An elementary study of electricity and magnetism correspondence course. It has many illustrations.

Millikan, R. A., and Bishop, E. S., *Elements of Electricity.* Chicago, American Technical Society, 1917.

First course in electricity for students who plan to make detailed study of electricity. Rather complex for high school students.

Molloy, E., *Practical Design of Small Motors and Transformers.* New York, Chemical Publishing Company, Inc., 1940.

A complete study of small electrical motors. Good for students of electricity in physics courses.

Moulton, F. D., and Schiffers, J. J., *The Autobiography of Science.* New York, Doubleday & Company, Inc., 1945.

This book is an anthology of the key passages from the master works of all sciences from very early times up until the present. It is arranged in chronological sequence by periods. It would be of value to high school students as a reference book for special assignments.

Nadon, J. M., and Gelmine, B. J., *Industrial Electricity.* New York, D. Van Nostrand Company, Inc., 1939.

This book is primarily designed for industrial, vocational, and technical schools. It is rather elementary but covers the field thoroughly.

Naidich, J., *Air Navigation Made Easy.* New York, McGraw-Hill Book Company, Inc., 1944.

This book is written for the average person who desires to become his own pilot. It requires no technical background and is rather easily understood.

Nyberg, J. A., *Fundamentals of Algebra, Book I.* New York, American Book Company, 1944.

A simple well-written algebra text used in many high schools.

Obourn, E. S., and Montgomery, G. C., *Fundamentals of Machines.* St. Louis, Webster Publishing Company, 1943.

Useful as a reference book for physics students.

Parker, B. M., *Our Ocean of Air.* New York, Row, Peterson & Company, 1941.

This pamphlet gives a good but simple explanation of the atmosphere and its constituents. Wind, air pressure, liquids, air and some simple classroom experiments pertaining to the atmosphere are also discussed. This booklet is on a junior high school level.

Perry, George S., *The Common Trees and Shrubs of Pennsylvania.* Harrisburg, Department of Forests and Waters, 1932.

This booklet contains a key and the scientific names of the common trees and shrubs of Pennsylvania both native and introduced. A good booklet for that part of high school biology that deals with plant identification. Probably of more value to the teacher than to the student.

Pieper, C. J., and Beauchamp, W. L., *Everyday Problems in Science.* New York, Scott, Foresman and Company, 1936.

This book breaks the environment up into seventeen units and treats each separately, first generally and then in detail. For ninth and tenth grade students.

Pieper, C. J., and others, *Everyday Problems in Biology.* Chicago, Scott, Foresman and Company, 1936.

This is a good book for ninth and tenth grade biology. It contains many pictures and illustrations, and the language is not too difficult.

Pope, F., and Otis, A. S., *Elements of Aeronautics.* New York, World Book Company, 1941.

This book is written in language that any high school pupil can understand. A knowledge of mathematics is not necessary.

Radio Corporation of America, *R. C. A. Receiving Tube Manual.* Camden, Radio Corporation of America, 1947.

This manual has been prepared to assist those who work or experiment with electronic tubes and circuits. It contains information on all types of radio tubes. Absolute necessity in the study of radio and construction.

Raehl, L. M., *Fitting Farm Tools.* Milwaukee, The Bruce Publishing Company, 1940.

This book tells how to repair broken or worn tools used around the farm, and would be useful as a reference book for high school students studying agriculture.

Ray, E. L., and Washburn, S., *Are You Fit to Be a Pilot?* Chicago, Wilcox and Follott Co., 1941.

Flight physical test to determine if students are physically fit to become pilots. Includes all types of tests that can be done in classroom. Excellent for high school preflight classes.

Renner, G. T., *Human Geography in the Air Age.* New York, The Macmillan Company, 1942.

This book is very readable, probably for senior students in high school or college students. It is intended primarily for air-minded people.

Rider, P. R., *Navigational Trigonometry.* New York, The Macmillan Company, 1943.

This is a book of trigonometry for those who wish to become pilots. It is rather difficult for high school students.

Ritchie, J. W., *Biology and Human Affairs.* New York, World Book Company, 1941.

A good book for students who are really interested in biology. Rather technical and not too practical for average students.

Shapely, H., and others, *A Treasury of Science.* New York, Harper and Brothers, 1946.

A very interesting and readable science book. Answers many questions concerning all phases of science.

Sharpe, C. F. S., *What is Soil Erosion?* Washington, U. S. Department of Agriculture, 1938.

A good booklet written in an easy-to-understand language. Useful for any course in high school when studying a unit on soils.

Slosson, E. E., *Creative Chemistry.* New York, Appleton-Century-Crofts, Inc., 1941.

This is a book on chemistry written especially for the layman. It is not intended to be used as a textbook.

Slosson, P. W., *After the War, What?* New York, Houghton Mifflin Company, 1943.

A good booklet for classes in social studies; also a good booklet for science classes in relation to the social phases of science.

Smith, D. E., *Essentials of Plane Geometry.* Boston, Ginn and Company, 1923.

Plane geometry carefully constructed from simple to complex.

Speas, R. D., *Airplane Performance and Operation.* New York, McGraw-Hill Book Company, Inc., 1943.

The purpose of this manual is to instruct flight crews in the various technical factors affecting airplane performance and operation. It would probably be useful in preflight courses in high school.

Stewart, J. Q., and Pierce, N. L., *Marine and Air Navigation.* New York, Ginn and Company, 1944.

For advanced students in aeronautics. Too technical for most high school students.

Stokley, James, *Electrons in Action.* New York, McGraw-Hill Book Company, Inc., 1946.

Clearly written, nontechnical, the book is packed with practical and realistic theories of what electronics may do for all of us tomorrow. An excellent reference book for high school science classes.

Stuart, J. R., *Wiring, Circuits for Lighting Power and Industrial Control.* New York, Chemical Publishing Company, 1941.

This book is much too difficult for the average high school student. It contains many wiring diagrams and explanations of electrical circuits which might be of use to physics students working on special projects.

Tarr, Ralph Stockman, *College Physiography.* New York, The Macmillan Company, 1947.

As the title indicates, this book is on college level, but it is of value as a reference book in high school, for teachers and students, when studying the atmosphere or specific earth problems encountered in a general science course.

Thomas Alva Edison Foundation, Inc., *The Incandescent Light.* West Orange, New Jersey, Thomas Alva Edison Foundation, Inc., 1949.

A very good explanation of the incandescent light from its infancy to the light we use today. High school students in science will find this book interesting and not too difficult. The book also includes information on the life of Edison and some of his other scientific accomplishments.

Timbie, W. H., *Elements of Electricity.* New York, John Wiley & Sons, Inc., 1937.

This book on electricity is designed primarily for a course in college physics. It can be easily understood by advanced high school physics students.

Tucker, D. J., *Introduction to Practical Radio.* New York, The Macmillan Company, 1945.

A very good reference book for information about radio. It would be of special interest to physics students working on radio projects.

U. S. Department of Agriculture, *Climate and Man.* Washington, U. S. Government Printing Office, 1941.

A large part of the volume is devoted to detailed discussion of the relation of climate and weather to crops. Many tables and maps dealing with weather all over the United States are included. A good reference book for agriculture students.

U. S. Dept. of Agriculture, *Yearbook of Agriculture.* Washington, U. S. Government Printing Office, 1936.

This book deals with creative development of new forms of life through plant and animal breeding. It would be of value to students studying agriculture.

U. S. Naval Institute, *Navigation and Nautical Astronomy.* Annapolis, U. S. Naval Institute, 1942.

This book is intended for advanced students in aeronautics. It might be useful as reference to students of preflight.

Verwiebe, F. L., *Elements of Machines.* New York, D. Van Nostrand Company, Inc., 1943.

This book intended for a training course for soldiers is useful for high school students as a reference book. Also as a reference book for teachers of high school science.

Wagener, Arthur, *The Machinists' and Draftsmen's Handbook.* New York, D. Van Nostrand Company, Inc., 1945.

Useful handbook for students of drafting and industrial arts. Much useful data is in tables.

Wellman, W. R., *Elementary Radio Servicing.* New York, D. Van Nostrand Company, Inc., 1947.

This book is for those who have already become interested in the principles of radio receiver construction.

Westinghouse Educational Foundation, *A Challenge to the World.* New York, McGraw-Hill Book Company, Inc., 1946.

This book contains about a dozen articles written by some of the outstanding engineers of the Westinghouse Corporation.

Westinghouse Educational Foundation, *Transportation, a Measurement of Civilization. Life, Light, and Man.* New York, McGraw-Hill Book Company, Inc., 1946.

This book contains a summary of some of the knowledge gained at the George Westinghouse Centennial Forum.

Whitbeck, R. N., *Economic Geography of South America.* New York, McGraw-Hill Book Company, Inc., 1926.

A helpful reference book for high school science courses when studying foods, textiles, rubber, etc. The book is on a college level.

White, M. W., *Experimental College Physics.* New York, McGraw-Hill Book Company, Inc., 1932.

This would be difficult for those who have not had high school physics. It could be used as a reference.

White, M. W., and others, *Practical Physics.* New York, McGraw-Hill Book Company, Inc., 1943.

In this book emphasis is placed on the parts of physics that are basic to practical use in engineering and technical work. The book is concise, at an introductory level, and therefore not too difficult for high school physics students.

Wolfe, J. H., *Simplified Industrial Mathematics.* New York, McGraw-Hill Book Company, Inc., 1942.

The purpose of this book is to familiarize the new student with the essentials of elementary industrial mathematics. Helpful for advanced high school mathematics students.

Free Publications

Commonwealth of Pennsylvania

Bulletin No. 5, November, 1949, *List of State Publications*, contains lists of many reports, maps, bulletins, laws, pamphlets, etc., which are available for free distribution. The various departments and commissions of our State Government have collaborated in this publication. Write to: Bureau of Publications, Department of Properties and Supplies, Harrisburg, for a copy.

Audio-Visual Aids

AUDIO-VISUAL AIDS AVAILABLE THROUGH THE DEPARTMENT OF PUBLIC INSTRUCTION

Bulletin 208, *Audio-Visual Aids Catalog,* lists institutions from which films may be borrowed and subjects of films and slides. This catalog is available in public school libraries and State teachers colleges.

Bulletin 517, *Science Slides*—Write to State Library and Museum, Lantern Slide Section, Harrisburg, Pa., for a copy of this bulletin. Here may be found an extensive source of free material.

OTHER AUDIO-VISUAL AIDS

In the material which follows there appears a partial list of 16mm motion picture films, sound and silent, and filmstrips. Fifty science teachers, widely distributed throughout the State, have found them successful in teaching the various sciences. *Approval by five or more of this jury has resulted in inclusion in this list.* Other visual aids are of excellent merit. These teaching aids and their use should be a matter of continuous investigation by science teachers.

Space will not permit the publication of all films available. However, catalogs and circulars may be obtained by writing to the sources listed in this book.

The following is a key to the abbreviations used as headings of the columns of data. The sources appear on page 350.

B	Buy	Sd	Sound
R	Rent	GS	General Science
F	Free	Bi	Biology
Fs	Filmstrip	P	Physics
Si	Silent	C	Chemistry

SOURCES, TITLES AND SUBJECTS

How Obtained B	R	F	*Title*	*Fs*	*Si*	*SD*	*GS*	*Bi*	*P*	*C*	*Source No.*
—	—	X	Story of Tuna	—	—	X	X	—	—	—	32
—	—	X	How a Watch Works	—	—	—	—	—	X	—	32
—	—	X	The Eternal Gem—Diamond	—	—	X	—	—	—	X	32
—	—	X	America's Favorites	—	—	X	X	—	—	—	32
—	—	X	Romance of Industry	—	—	—	—	—	—	X	32
X	—	—	Electrolysis	X	—	—	—	—	—	X	33
X	—	—	Ionization	X	—	—	—	—	—	X	33
X	—	—	The Electron Theory	X	—	—	—	—	—	X	33
X	—	—	Metallurgy	X	—	—	—	—	—	X	33
X	—	—	Nomenclature	X	—	—	—	—	—	X	33
X	—	—	Producing Crude Oil	—	X	—	—	—	—	X	4
X	—	—	Refining Crude Oil	—	X	—	—	—	—	X	4
X	—	—	Refrigeration	—	X	—	—	—	—	X	4
X	—	—	Rubber	—	X	—	—	—	—	X	4
X	—	—	Silk	—	X	—	—	—	—	X	4
X	—	—	Cotton	—	X	—	—	—	—	X	4

How Obtained B	R	F	*Title*	*Fs*	*Si*	*SD*	*GS*	*Bi*	*P*	*Source* C	*No*
X	—	—	Woolen Goods	—	X	—	—	—	—	X	
X	—	—	Electrons, an Introduction	—	X	—	—	—	—	X	
—	—	X	Clean Waters	—	—	X	—	—	—	X	2
—	—	X	Prospecting for Oil	—	—	X	—	—	—	X	1
X	—	—	Velocity of Chemical Reactions	—	—	X	—	—	—	X	
X	—	—	Nitrogen Cycle	—	X	—	—	—	—	X	
X	—	—	Soap	—	—	X	—	—	—	X	
—	—	X	Harnessing the Rainbow	—	—	X	—	—	—	X	1
—	—	X	Plant Food from Coal	—	—	X	—	—	—	X	
—	—	X	Curiosity Shop	—	—	X	—	—	—	X	
X	—	—	Copper Refining and Smelting	—	X	—	—	—	—	X	
—	—	X	Heritage of Glass	—	—	X	—	—	—	X	
—	—	X	Science Spins a Yarn	—	—	X	—	—	—	X	3
X	—	—	Story of Electricity	—	—	X	—	—	X	—	
X	—	—	What is Color?	—	—	X	—	—	X	—	
X	—	—	Simple Machines	—	X	—	—	—	X	—	
X	—	—	Behavior of Light	—	X	—	—	—	X	—	
X	—	—	Compressed Air	—	X	—	—	—	X	—	
X	—	—	The Electron	—	—	X	—	—	X	—	
—	—	X	Elementary Electricity	—	—	X	—	—	X	—	2
X	—	—	Four-Cycle Gas Engine	—	X	—	—	—	X	—	
X	—	—	Fuel and Heat	—	—	X	—	—	X	—	
X	—	—	Heat and Light from Electricity	—	X	—	—	—	X	—	
X	—	—	Hot Air Heating	—	X	—	—	—	X	—	
X	—	—	Illumination	—	X	—	—	—	X	—	
X	—	—	Lenses	—	X	—	—	—	X	—	
X	—	—	Induced Currents	—	X	—	—	—	X	—	
X	—	—	Magnetic Effects of Electricity	—	X	—	—	—	X	—	
X	—	—	Principles of Flight	—	X	—	—	—	X	—	
—	—	X	Heart and Circulation	—	—	X	—	X	—	—	2
—	—	X	Mechanism of Breathing	—	—	X	—	X	—	—	2
—	—	X	The Nervous System	—	—	X	—	X	—	—	2
—	—	X	Immunization	—	—	X	—	X	—	—	2
—	—	X	Control of Body Temperature	—	—	X	—	X	—	—	2
—	—	X	How Teeth Grow	—	—	X	—	X	—	—	2
—	—	X	Foods and Nutrition	—	—	X	—	X	—	—	2
—	—	X	Health and the Cycle of Water	—	—	X	—	X	—	—	2
—	—	X	Care of the Feet	—	—	X	—	X	—	—	2
—	—	X	Endocrine Glands	—	—	X	—	X	—	—	2
—	—	X	Heart Disease	—	—	X	—	X	—	—	2
—	—	X	Quality Milk Production	—	—	X	—	X	—	—	2
—	—	X	Alimentary Tract	—	—	X	—	X	—	—	2
—	—	X	Heredity	—	—	X	—	X	—	—	2
—	—	X	Green Harvest	—	—	X	X	—	—	—	
—	—	X	Crystal of Energy	—	—	X	—	—	—	X	
—	—	X	Unfinished Rainbows	—	—	X	X	—	—	—	
—	—	X	Trees to Tribunes	—	—	X	X	—	—	—	
—	—	X	Curves of Color	—	—	X	—	—	X	—	
—	—	X	Sand and Flame	—	—	X	—	—	—	X	1
—	—	X	Eternal Flame	—	—	X	X	—	—	—	
—	—	X	Curiosity Shop	—	—	X	X	—	—	—	
—	—	X	Magnesium—Metal from the Sea	—	—	X	—	—	—	X	2
—	—	X	Story of Gasoline	—	—	X	—	—	—	X	2
—	—	X	Clean Waters	—	—	X	X	X	—	—	
—	—	X	Excursions in Science No. 4	—	—	X	X	—	—	—	

How Obtained B	R	F	Title	Fs	Si	SD	GS	Bi	P	C	Source No.
—	—	X	Excursions in Science No. 9	—	—	X	X	—	—	—	3
—	—	X	Excursions in Science No. 1	—	—	X	X	—	—	—	3
—	—	X	Ever Since Eden	—	—	X	X	—	—	—	2
—	—	X	Story of the Storage Battery	—	—	X	—	—	X	—	23
—	—	X	Precisely So	—	—	X	X	—	—	—	11
—	—	X	Volcanoes in Action	—	—	X	X	—	—	—	9
—	—	X	Work of the Atmosphere	—	—	X	X	—	—	—	9
—	—	X	Ground Water	—	—	X	X	—	—	—	9
X	—	—	The Respiratory System	X	—	—	X	X	—	—	18
X	—	—	The Glandular System	X	—	—	X	X	—	—	18
X	—	—	The Digestive System	X	—	—	X	X	—	—	18
X	—	—	The Circulatory System	X	—	—	X	X	—	—	18
X	—	—	The Nervous System	X	—	—	X	X	—	—	18
—	—	X	Jet Propulsion	—	X	—	—	—	X	—	3
—	—	X	Harnessing Liquids	—	X	—	X	—	—	—	3
—	—	X	Magic of Fluorescence	—	X	—	X	—	—	—	3
—	—	X	Curves of Color	—	X	—	—	—	X	—	3
—	—	X	Birth of an Oil Field	—	X	—	—	—	—	X	3
—	—	X	Metal Magic	—	X	—	—	—	—	X	3
—	—	X	Gyro Compass	—	X	—	—	—	X	—	3
—	—	X	Radio Frequency Heating	—	X	—	—	—	X	—	3
—	—	X	Singing Wires	—	X	X	—	—	—	—	3
—	—	X	Magic in the Air	—	X	—	—	—	X	—	11
—	—	X	Basic Principles of Lubrication	—	X	—	—	—	X	—	11
—	—	X	ABC of Automobile Engines	—	X	—	—	—	X	—	11
—	—	X	ABC of Internal Combustion	—	X	—	—	—	X	—	11
—	—	X	Heat and Its Control	—	X	—	—	—	X	—	23
—	—	X	Frontiers of the Future	—	X	—	—	—	—	X	11
—	—	X	The Story of Copper	—	X	—	—	—	—	X	23
—	—	X	This Is Aluminum	—	X	—	—	—	—	X	23
—	—	X	The Drama of Steel	—	X	—	—	—	—	X	23
—	—	X	Lever Age	—	X	X	—	—	—	—	12
—	—	X	Life Blood of Land	—	X	X	—	—	—	—	27
—	—	X	Principles of Electricity	—	X	X	—	—	—	—	3
—	—	X	Clouds	—	X	X	—	—	—	—	34
—	—	X	Lubrication	—	X	—	—	—	X	—	23
—	—	X	Quiet, Please!	—	X	—	—	—	X	—	26
—	—	X	Application of Pascal's Law	—	X	—	—	—	X	—	31
X	—	—	How Nature Protects Animals	—	—	X	—	X	—	—	4
—	—	X	Realm of the Wild	—	—	X	—	X	—	—	1
—	—	X	Timber Is a Crop	—	—	X	—	X	—	—	1
X	—	—	Living Jewels	—	X	—	—	X	—	—	21
X	—	—	Undersea Life	—	X	—	—	X	—	—	21
—	—	X	Precious Ingredient	—	—	X	—	X	—	—	13
X	—	—	Three Brains	—	—	X	—	X	—	—	8
X	—	—	Ships of the Desert	—	X	—	—	X	—	—	4
X	—	—	Cat Tribe, Racoons	—	X	—	—	X	—	—	4
X	—	—	Bacteria	—	X	—	—	X	—	—	4
X	—	—	Beavers	—	X	—	—	X	—	—	4
X	—	—	Seals and Walrus	—	X	—	—	X	—	—	4
X	—	—	Roads and Erosion	—	—	X	—	X	—	—	1
X	—	—	Leaves	—	—	X	—	X	—	—	4
X	—	—	Green Plants	—	X	—	—	X	—	—	4
X	—	—	Wild Flowers	—	X	—	—	X	—	—	4
X	—	—	Fungus Plants	—	X	—	—	X	—	—	4

How Obtained B	R	F	Title	Fs	Si	SD	GS	Bi	P	Source C	No.
X	—	—	Luther Burbank	—	X	—	—	X	—	—	4
X	—	—	Flower to Fruit	—	X	—	—	X	—	—	4
X	—	—	The River	—	—	X	—	X	—	—	1
X	—	—	Seashore Animals	—	X	—	—	X	—	—	4
—	X	—	Wild Life in Pennsylvania	—	—	X	—	X	—	—	22
—	—	X	For Years to Come	—	—	X	—	X	—	—	1
—	—	X	Forests Forever	—	—	X	—	X	—	—	1
X	—	—	Birds of Prey	—	X	—	—	X	—	—	4
X	—	—	Some Friendly Birds	—	X	—	—	X	—	—	4
X	—	—	Oyster	—	X	—	—	X	—	—	4
X	—	—	Flowers at Work	—	X	—	—	X	—	—	4
X	—	—	Muddy Waters	—	—	X	—	X	—	—	1
X	—	—	Terracing in the North East	—	—	X	—	X	—	—	1
—	—	X	Report on DDT	—	—	X	—	X	—	—	4
X	—	—	Frogs, Toads and Salamanders	—	X	—	—	X	—	—	4
X	—	—	Roots of Plants	—	—	X	—	X	—	—	4
X	—	—	How the Ear Functions	—	—	X	—	X	—	—	4
X	—	—	How the Eye Functions	—	—	X	—	X	—	—	4
X	—	—	Life Cycle of the Mosquito	—	—	X	—	X	—	—	25
X	—	—	Light Waves	—	—	X	X	—	—	—	4
X	—	—	Carbon Oxygen Cycle	—	X	—	X	—	—	—	4
X	—	—	Water Cycle	—	X	—	X	—	—	—	4
—	—	X	It's No Picnic	—	—	X	X	—	—	—	1
X	—	—	Iron Ore to Pig Iron	—	X	—	X	—	—	—	4
X	—	—	Pig Iron to Steel	—	X	—	X	—	—	—	4
X	—	—	Simple Machines	—	X	—	X	—	—	—	4
X	—	—	Magnetic Effects of Electricity	—	X	—	X	—	—	—	4
—	X	—	Chemistry of Fire	—	—	X	X	—	—	—	15
—	—	X	The Balanced Way	—	—	X	X	—	—	—	8
X	—	—	Water	—	—	X	X	—	—	—	15
X	—	—	Clouds and Weather	—	X	—	X	—	—	—	8
X	—	—	Weather Forecasting	—	X	—	X	—	—	—	4
—	—	X	Frontiers of the Future	—	—	X	X	—	—	—	12
—	—	X	Scientists for Tomorrow	—	—	X	X	—	—	—	12
—	—	X	Sulfur	—	—	X	X	—	—	—	23
X	—	—	Sulfur and Its Compounds	—	—	X	X	—	—	—	24
—	X	—	Prospecting for Water	—	—	X	X	—	—	—	10
X	—	—	Limestone and Marble	—	X	—	X	—	—	—	4
X	—	—	Halogens	—	—	X	—	—	—	X	7
X	—	—	Colloids	—	—	X	—	—	—	X	4
X	—	—	Properties of Water	—	—	X	—	—	—	X	7
—	—	X	Bouncing Molecules	—	—	X	—	—	—	X	14
X	—	—	Oxygen	—	—	X	—	—	—	X	7
—	—	X	Crystal Gazers	—	—	X	—	—	—	X	3
X	—	—	Chemical Reactions	—	—	X	—	—	—	X	5
X	—	—	Our Common Fuels	—	—	X	—	—	—	X	7
X	—	—	Tin	—	X	—	—	—	—	X	4
X	—	—	Beet and Cane Sugar	—	X	—	—	—	—	X	4
X	—	—	Chemical Effects of Electricity	—	X	—	—	—	—	X	4
—	—	X	Chemistry of Fire	—	—	X	—	—	—	X	20
X	—	—	Common Salt	—	X	—	—	—	—	X	4
X	—	—	Fuel and Heat	—	—	X	—	—	—	X	4
X	—	—	Gold	—	X	—	—	—	—	X	4
X	—	—	Oxidation and Reduction	—	—	X	—	—	—	X	4
X	—	—	Refrigeration	—	X	—	—	—	X	—	4

How Obtained B	R	F	Title	Fs	Si	SD	GS	Bi	P	Source C	No.
X	—	—	Steam Power	—	X	—	—	—	X	—	4
X	—	—	Measurements and Measuring Series I	X	—	—	—	—	X	—	15
X	—	—	Measurements and Measuring Series II	X	—	—	—	—	X	—	15
X	—	—	Electrons	X	—	—	—	—	X	—	16
X	—	—	Mechanics I	X	—	—	—	—	X	—	16
X	—	—	Mechanics II	X	—	—	—	—	X	—	16
X	—	—	Pilots Man Your Planes	X	—	—	—	—	X	—	15
—	—	X	Research Engineer Aircraft Division	X	—	—	—	—	X	—	15
—	—	X	The Artist Portrays the Oil Industry	X	—	X	—	—	—	—	14
X	—	—	Madame Curie and the Story of Radium	X	—	X	—	—	—	—	17
X	—	—	Atmosphere	X	—	X	—	—	—	—	16
X	—	—	Fire and Fuel	X	—	X	—	—	—	—	18
X	—	—	How Disease Is Spread	X	—	X	—	—	—	—	18
X	—	—	Meteorology and Navigation	X	—	X	—	—	—	—	15
X	—	—	Seeds and Seed Dispersal	X	—	X	—	—	—	—	18
X	—	—	Splendor of the Sky and Birth of the Earth	X	—	X	—	—	—	—	16
X	—	—	Air	X	—	X	—	—	—	—	16
X	—	—	Electricity	X	—	X	—	—	—	—	16
X	—	—	Energy	X	—	X	—	—	—	—	16
X	—	—	Fuels and Heat	X	—	X	—	—	—	—	16
X	—	—	Inclined Plane	X	—	X	—	—	—	—	16
X	—	—	Levers	X	—	X	—	—	—	—	16
X	—	—	Light	X	—	X	—	—	—	—	16
X	—	—	Magnetism	X	—	X	—	—	—	—	16
X	—	—	Pulleys	X	—	X	—	—	—	—	16
X	—	—	Sound	X	—	X	—	—	—	—	16
X	—	—	Water	X	—	X	—	—	—	—	16
X	—	—	Optical Illusions	X	—	X	—	—	—	—	16
X	—	—	Along the Redwood Trail	X	—	—	—	X	—	—	16
X	—	—	Beaks and Feet of Birds	X	—	—	—	X	—	—	16
X	—	—	Coloration of Birds	X	—	—	—	X	—	—	16
X	—	—	Eccentricities of Wasps and Bees	X	—	—	—	X	—	—	16
X	—	—	From One-Celled Life to Amphibians	X	—	—	—	X	—	—	16
X	—	—	Fur Seal	X	—	—	—	X	—	—	16
X	—	—	How Disease Is Spread	X	—	—	—	X	—	—	16
X	—	—	Our Forests and What They Mean to Us	X	—	—	—	X	—	—	16
X	—	—	Plant Life	X	—	—	—	X	—	—	16
X	—	—	Relation of Insects to Disease	X	—	—	—	X	—	—	16
X	—	—	Seeds and Seed Dispersal	X	—	—	—	X	—	—	16
X	—	—	Some Insect Life Histories	X	—	—	—	X	—	—	16
X	—	—	Spring Wildflowers of Open Fields	X	—	—	—	X	—	—	16
X	—	—	Summer Wildflowers	X	—	—	—	X	—	—	16
X	—	—	Animal Parade From Sea Anemone to Man	X	—	—	—	X	—	—	16
X	—	—	Food From the Sun	X	—	—	—	X	—	—	16
X	—	—	How Color Protects Animals	X	—	—	—	X	—	—	16
X	—	—	How Insects Get Their Food	X	—	—	—	X	—	—	16
X	—	—	How Insects Grow Up	X	—	—	—	X	—	—	16
X	—	—	Some Desert Animals and How They Live	X	—	—	—	X	—	—	18
X	—	—	Some Frogs, Toads, and Salamanders	X	—	—	—	X	—	—	16
X	—	—	Some Lizards, Snakes, and Toads	X	—	—	—	X	—	—	16
X	—	—	The Life of the Horned Lark	X	—	—	—	X	—	—	16
X	—	—	Life of the Swallow-tailed Butterfly	X	—	—	—	X	—	—	16
X	—	—	Chlorine and Its Compounds	X	—	—	—	—	—	X	16
X	—	—	Flax and Linen	X	—	—	—	—	—	X	16
X	—	—	Iron	X	—	—	—	—	—	X	16

How Obtained B	R	F	*Title*	*Fs*	*Si*	*SD*	*GS*	*Bi*	*P*	*Source* C	No.
X	—	—	Petroleum	X	—	—	—	—	—	X	16
X	—	—	Steel	X	—	—	—	—	—	X	16
X	—	—	Story of Copper	X	—	—	—	—	—	X	16
X	—	—	Atomic Theory	X	—	—	—	—	—	X	16
X	—	—	Carbon and Calcium	X	—	—	—	—	—	X	16
X	—	—	Hydrogen and Water	X	—	—	—	—	—	X	16
X	—	—	Ions and Nitrogen	X	—	—	—	—	—	X	16
X	—	—	Metals	X	—	—	—	—	—	X	16
X	—	—	Ogygen	X	—	—	—	—	—	X	16
—	—	X	Your Future in Trees	—	—	X	—	X	—	—	29
—	—	X	Alaska's Silver Millions	—	—	X	—	X	—	—	30
—	—	X	Industry for Health	—	—	X	—	X	—	—	2
X	—	—	The Structure of Matter	X	—	—	—	—	X	—	15
X	—	—	Effects of Molecular Motion	X	—	—	—	—	X	—	15
X	—	—	Molecular Forces in Matter	X	—	—	—	—	X	—	15
X	—	—	Molecular Forces in Liquids	X	—	—	—	—	X	—	15
X	—	—	Bernoulli's Principle	X	—	—	—	—	X	—	15
X	—	—	Uniform Motion	X	—	—	—	—	X	—	15
X	—	—	Centrifugal Force	X	—	—	—	—	X	—	15
X	—	—	Newton's Laws of Motion	X	—	—	—	—	X	—	15
X	—	—	Simple Machines	X	—	—	—	—	X	—	15
X	—	—	Static Electricity	X	—	—	—	—	X	—	15
X	—	—	Magnetism	X	—	—	—	—	X	—	15
X	—	—	Electromagnetism	X	—	—	—	—	X	—	15
X	—	—	Current Electricity	X	—	—	—	—	X	—	15
X	—	—	Electric Motors	X	—	—	—	—	X	—	15
X	—	—	Alternating Current	X	—	—	—	—	X	—	15
X	—	—	The Generator	X	—	—	—	—	X	—	15
X	—	—	The Ignition System	X	—	—	—	—	X	—	15
—	—	X	Manufactured Abrasives	—	—	X	—	—	—	X	23
—	—	X	Evolution of Oil Industry	—	—	X	—	—	—	X	23
—	—	X	Stainless Steel	—	—	X	—	—	—	X	23
—	—	X	Synthetic Rubber	—	—	X	—	—	—	X	23
—	—	X	Masters of Molecules	—	—	X	—	—	—	X	32

SOURCE OF FILMS AND FILMSTRIPS

1. U. S. Forest Service, Department of Agriculture, Washington 25, D. C.
2. Modern Talking Picture Service, 108 North 17th Street, Philadelphia 3.
3. General Electric Company, Visual Instruction Section, 1 River Road, Schenectady, New York.
4. Encyclopædia Britannica Films, 20 North Wacker Drive, Chicago 6, Illinois.
5. Edited Pictures System, Inc., 165 West 46th Street, New York 19, New York.
6. Du Pont de Nemours Company, Rayon Division, Empire State Building, New York, New York.
7. Coronet Instructional Films, 65 East South Water Street, Chicago 1, Illinois.
8. Castle Films, RCA Building, Rockefeller Plaza, New York 20, New York.
9. The Pennsylvania State College, Audio-Visual Aids, State College.
10. Kuntz Motion Picture Service, 1319 Vine Street, Philadelphia.
11. General Motors Corp., Department of Public Relations, General Motors Building, Detroit, Michigan.
12. Shell Oil Company, 50 West 50th Street, New York 19, New York.

13. Westinghouse Electric Company, 306 Fourth Avenue, P. O. Box 1017, Pittsburgh.
14. Esso Standard Oil Company, Real Estate Trust Building, Philadelphia.
15. Jam Handy Organization, 1775 Broadway and 72nd Street, New York 23, New York.
16. Stanley Bowmar, 2067 Broadway and 72nd Street, New York 23, New York.
17. Pictorial Events, 597 Fifth Avenue, New York 17, New York.
18. Society for Visual Education, Inc., Chicago, Illinois.
19. Sugar Research Foundation, Inc., Box 137, Wall Street Station, New York, New York.
20. United States Navy Department, Washington 25, D. C.
21. Library Film Company, 25 West 45th Street, New York, New York.
22. American Museum of Natural History, New York, New York.
23. U. S. Bureau of Mines, 4800 Forbes Street, Pittsburgh 13.
24. Ideal Picture Corporation, 207 East 37th Street, New York, New York.
25. Young America Films, 18 East 41st Street, New York, New York.
26. Celotex Corporation, 120 So. LaSalle Street, Chicago 3, Illinois.
27. Department of Forests and Waters, Harrisburg.
28. Department of Health, Harrisburg.
29. Davey Tree Expert Company, Kent, Ohio.
30. American Can Company, 230 Park Avenue, New York 17, New York.
31. Civil Aeronautics Adm., Washington 25, D. C.
32. Association Films, Inc., 35 West 45th Street, New York 19, New York.
33. Welch Scientific Company, Chicago, Illinois.
34. Weather Bureau, U. S. Department of Commerce, Washington 25, D. C.

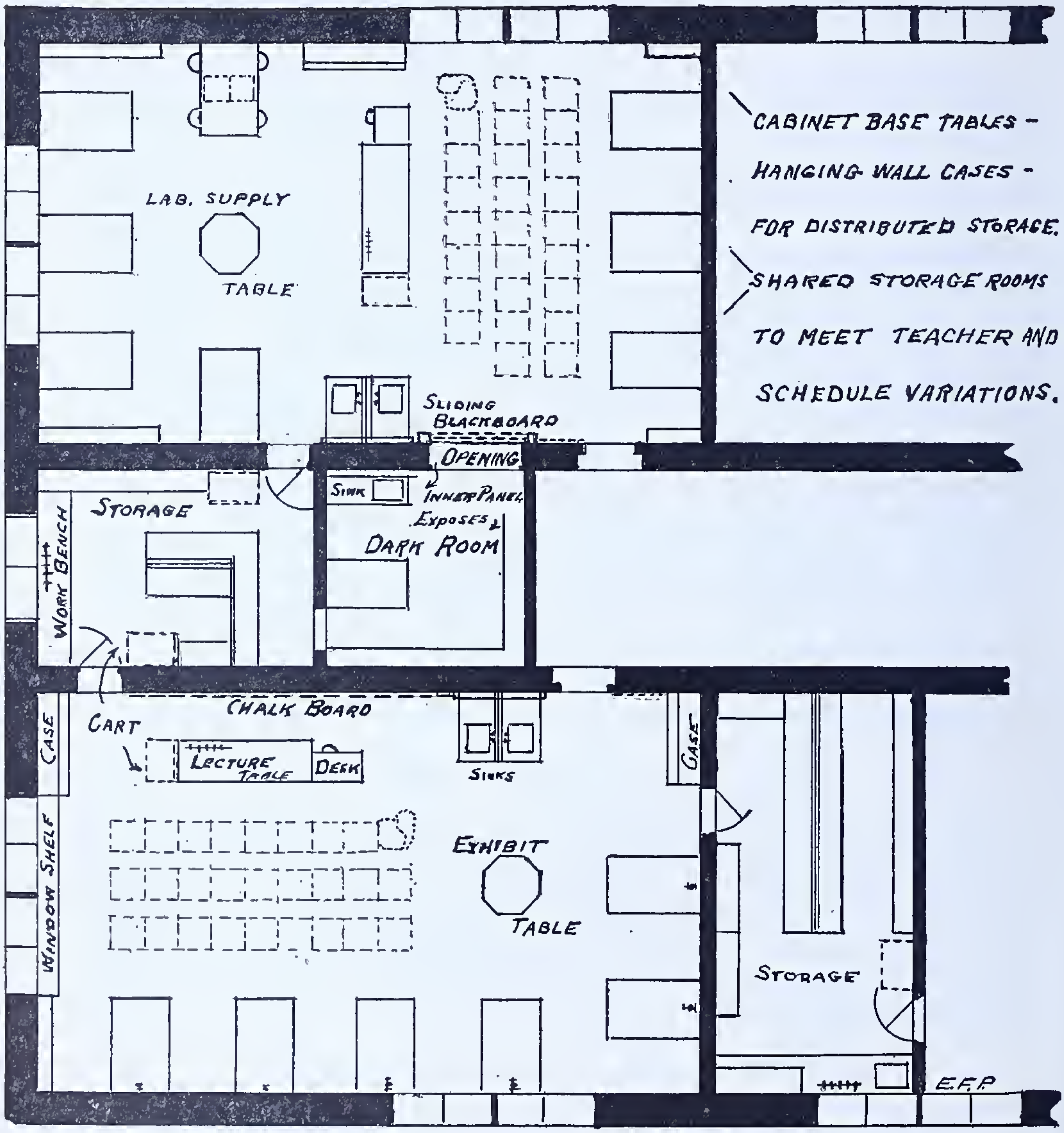
SCIENCE ROOM PLANNING PAVES THE WAY

Science rooms should be designed to provide the means to the goals of science education. Learning will always take place; certain behaviors will be modified and new patterns will develop. But what types of learning and what types of behavior are important. It is the duty of the teacher, the administrator, the architect, and the school board member to see that the physical environment is conducive to the development of the types of behavior which are set as goals. The means of instruction must be set up so that they do not simply challenge youth but actually reflect a clear image of the "operative philosophy" of science.

Materials should show, in their presence and condition, the efficiency which develops skills in observation, techniques of reading and expression, and the use of factual knowledge in making and testing hypotheses. Only through the purchase and proper use of the tangible factors will proper scientific attitudes develop and self-confidence and maturity be achieved.

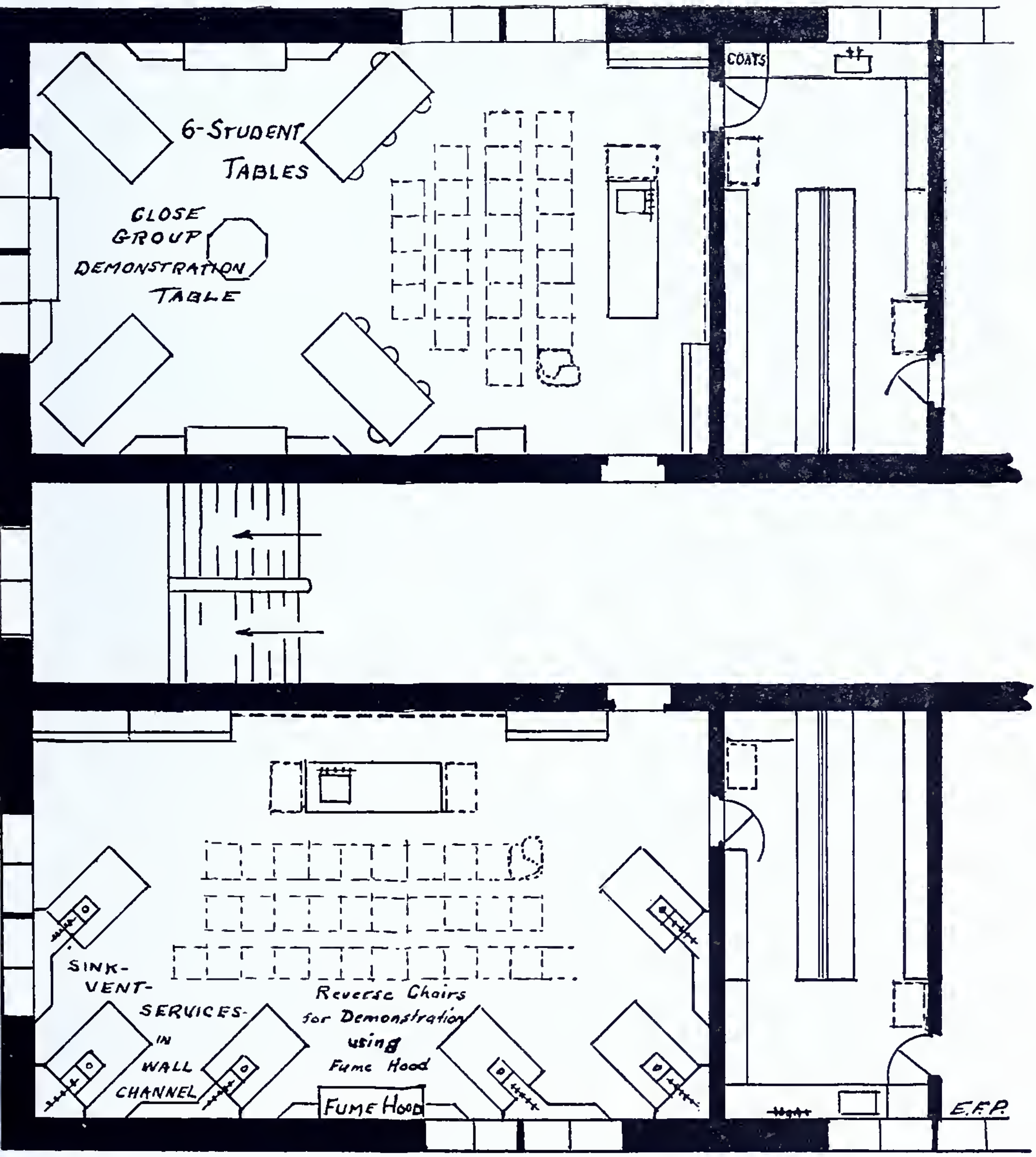
It is not implied that attainment must be dependent upon expensive equipment and an elaborate layout. A science room, above all others, should be adapted to the latest developments of science. The creative use of very meager facilities results in achievement beyond that of many of the finest laboratories. The surface has been barely scratched in the use of resources found in every home and community, rural and urban, industrial and agricultural.

The type of science room will vary from the all-purpose science room in the small school to the highly specialized academic laboratory in the



A SCIENCE CLASSROOM AND LABORATORY

large city high school. Insofar as the former does not blindly accept the standard pattern of the latter, or follow either a traditional or college-dominated example, we may hope for improvement. Certain physical equipment reflecting the common learning for all pupils will be common to all science rooms. For the most part, however, the equipment should reflect very definitely its adaptation to local community needs and local student concerns and interests. Insofar as special rooms—adapted to the specific subject matter areas—make possible a richer experience, such a tendency is good. Insofar as the all-purpose room contributes to the understanding of the common factors of all science fields and its natural integration with all subject matter fields, it, too, is good.



A MODIFIED PLAN FOR THE SCIENCE CLASS AND LABORATORY

Special talent may lie in varied or comprehensive fields as well as in fields of narrow specialization. This talent may be served in general all-purpose science rooms as well as in the specialized academic laboratory.

Science rooms must be flexible enough to provide for experimentation not only in the natural science itself, but for teacher experimentation in science education. Sound building construction reflects solid substance

and permanence. New ideas develop in education and should be given fair trial in regard to the proper physical environment as well as in regard to other factors. Flexible or varied use of rooms requires careful planning but not necessarily a sacrifice in sound building construction. Philosophy, in this regard, may parallel that in regard to the curriculum.

There are certain unchanging elements in sound building construction; there are certain unchanging elements in sound curriculum construction. But beyond that point there should be the utmost freedom and opportunity for adaptation to changing method and for creative development. The all-purpose room plans on pages 352 and 353 are designed to make a functional science education program more effective. An examination of them may reveal the following advantages:

Special Advantages of the Suggested Class and Laboratory Plan

1. Waste walking or corridor space reduced from the usual 50 per cent or more of floor space to about 20 per cent.
2. Saves teacher walking time and energy.
3. Teacher within easy range of all students for help in case of emergency.
4. Simpler and smaller floor area to clean.
5. Easy flow of students from lecture area to work area and in and out of the room.
6. More individual working area with less crowding back to back.
7. Facilities for weighing and distribution of materials centered and distributed so that room traffic is reduced to a minimum.
8. Individual storage facilities in each area reduce room traffic and apparatus breakage.
9. All services—water, waste, vents, gas, electricity—in a common channel, concentrated on most convenient walls.
10. No obstructions—water pipes, reagent shelves, support rods, vent pipes—in the center of the room to obstruct view of pupils or hide pupils from view of instructor.
11. New features generally made to contribute to greater safety and economy.
12. Adaptable equally well to chemistry, physics, biology, or general science with only slight modification of plans.
13. Meets the diversified needs of new curriculum planning.
14. Provides a physical setup from which a more natural, progressive and individualized program can evolve.

APPENDIX

ACKNOWLEDGMENTS

In the preparation of this progress report, a representative from the field of science education has been selected by every county and district superintendent in the Commonwealth. These participants have received a letter of appointment from Francis B. Haas, Superintendent of Public Instruction, naming them as members of district science curriculum committees. Nine district committees of this type have been organized. The cooperation of the superintendents has made this wide participation possible.

The chairmen of the nine district committees and elected officers of the Science Round Table of the Pennsylvania State Education Association have made up the State Committee. The names of these persons are listed on page iv.

State committee members have assembled their district committee members frequently for recommendations and reports. Out of these conferences and the class work of teachers, the material for this progress report has been developed.

The cooperation and hospitality of the following sponsoring institutions have made the semiannual area curriculum conferences possible:

Edinboro State Teachers College
Indiana State Teachers College
Lehigh University
Lock Haven State Teachers College
Pennsylvania College for Women
Slippery Rock State Teachers College
University of Pennsylvania
University of Pittsburgh
Wilkes College

This pattern of local and State activity will be continued while this progress report is tried out and evaluated and further contributions are made for its revision.

The wholehearted and sincere cooperation of the following district science curriculum committee members is creating new horizons of education in Pennsylvania.

W. E. Strawinski, Editorial Assistant, has edited the copy of this bulletin.

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